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DIETARY ALLOWANCES FOR INDIANS

By

C. GOPALAN

AND

B. S. NARASINGA RAO

NATIONAL INSTITUTE OF NUTRITION

Indian Council of Medical Research

HYDERABAD - 500 007

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CONTENTS

		Page
1. INTRODUCTION	...	1
2. CALORIES	...	4
3. PROTEINS	...	7
4. FAT	...	27
5. CALCIUM	...	29
6. IRON	...	35
7. VITAMINS	...	41
Vitamin A	...	46
Vitamin D	...	51
Vitamin C	...	53
Thiamine	...	56
Riboflavin	...	60
Nicotinic acid	...	64
Vitamin B_{12}	...	67
Folic acid	...	69
Summary	...	71
8. AREAS FOR FURTHER RESEARCH	...	75
APPENDIX	...	78

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1. INTRODUCTION

The Nutrition Advisory Committee (N.A.C.) of the Indian Council of Medical Research (I.C.M.R.), in 1944, recommended dietary allowances of calories, proteins, iron, calcium, Vitamin A, thiamine, ascorbic acid and Vitamin D for different groups (Table 1). These recommendations were based partly on recommendations of the League of Nations, the National Research Council (N.R.C.) of the United States of America, the National Research Council of Canada, and the Medical Research Council (M.R.C.) of the United Kingdom ; and partly on data collected by Indian workers.

The original recommendations of the Nutrition Advisory Committee of the year 1944 have not been revised and brought up-to-date except for calories and proteins, which were revised in 1958(Patwardhan, 1960). Our concepts of human nutrient requirements have been changing with newer knowledge. Recommended allowances of nutrients, have therefore, been revised periodically and brought up-to-date by the National Nutrition Advisory Bodies of several countries. Expert Committees of the Food and Agrieulture Organization and the World Health Organization have also considered this question and recommended the figures for calories, proteins, calcium and several vitamins. In view of the changes in our concept of human requirements of several nutrients as a result of knowledge gathered over the past twentyfive years, a review of nutrient allowances for Indians is overdue and the earlier recommendations have to be brought up-to-date. A fair amount of research carried out in India on the nutrient requirements of Indians during the last two decades, justifies undertaking the revision of the recommended allowances on the basis of Indian data.

This report concerns itself with dietary allowances of calories, proteins, fat, calcium, iron, Vitamin A, Vitamin D, thiamine, riboflavin, niacin, ascorbic acid, Vitamin B_{12} and folic acid for Indians. Available data, based on work done in India, have been reviewed and dietary allowances of nutrients for different groups suggested in the light of these data.

The Nutrition Expert Group of Indian Council of Medical Research at its meeting held at the Nutrition Research Laboratories. Hyderabad, in June 1968, considered this report and formulated recommendations regarding dietary allowances of calories, proteins, fat, calcium, iron, Vitamin A, thiamine, riboflavin, niacin, ascorbic acid, Vitamin B_{12}. folic acid and Vitamin D for Indians. The Nutrition Expert Group recommended balanced diets for different groups based on these nutrient allowances. These recommendations are given in Appendix I.

TABLE 1

Dietary Allowances of Nutrients for Indians
Recommended by the Nutrition Advisory Committee of the I. C. M. R., 1944.

			Net calories*	Protiens (gm.)	Calcium (gm.)	Iron (mg.)	Vitamin A (I.U.)	Thiamine (mg.)	Ascorbic acid (mg.)	Vitamin D (I.U.)
Man (55 kg. or 120 lbs)	Sedentary work		2400	55*	1.0	20 to 30	3000 to 4000	1.0 to 2.0	50	
	Moderate work		2800							
	Heavy work		3900							
Woman (45 kg. or 100 lbs.)	Sedentary work		2000	45*						
	Moderate work		2300							
	Heavy work		3000							
	Pregnancy (Latter half)		2300	100	1.5					400 to 800
	Lactation		2700	110	2.0					
Children :	0 to 6 months		120/kg.	3.5/kg.	1.0 to 1.5	10 to 30	3000 to 4000	0.5 to 1.0	30 to 50 and over.	400 to 800
	7 to 12 months		100/kg.							
	1 to 3 years		1200							
	4 to 5 ,,		1500							
	5 to 6 ,,		1500							
	6 to 7 ,,		1800							
	7 to 9 ,,		1800							
	10 to 12 ,,		2130							
Adolescents	13 to 15 ,,	Girls	2100	3.0/kg.						
		Boys	2500							
	16 to 19 ,,	Girls	2100	2.0/kg.						
		Boys	3150							

* Revised scales recommended in 1958.

References

1. Nutrition Advisory Committee of the India Research Fund Association (Now I. C. M, R.) (1944) ... Report of the Twelfth Meeting (1944)
2. Patwardhan, V. N, (1960) ... Dietary allowances for Indians. Calories and proteins. Indian Council of Medical Research .

2. CALORIES

The calorie allowances recommended by the Nutrition Advisory Committee are given in Table 1. The basis for the revised recommendations of 1958 has been fully discussed by Patwardhan in an earlier publication (1960). Though there appear to be no significant additional data on calorie requirements of Indians to justify any general revision of these recommendations, calorie allowances in respect of some categories need further evaluation.

2. 1. Adults :

The calorie requirements of adult men and women were estimated by the activity breakdown method, employing available data for basal metabolic rate and the energy cost of different activities determined in Indians. Though there were no differences in the computed values and the recommended figures for calorie requirement for adult men, there was some discrepancy between these figures in the case of adult women for sedentary and moderate work. Whereas the computed values for these two types of activities were 1790 and 2080, the recommended allowances were 2000 and 2300 respectively. The reason for this difference is not clear. It is true that in the earlier estimation of calorie requirement of women, no allowance was made for increased calorie requirement due to increased body-temperature during the menstrual cycle, but additional calorie intake on this account will not account for more than 50–60 calories per day. In view of this discrepancy, recommended calorie allowances for adult women engaged in sedentary and moderate work need to be revised. The revised figures for calorie allowance for adult women, after taking into consideration the extra needs due to increased body-temperature during menstrual cycle, will be 1900 and 2200 calories per day for sedentary and moderate work respectively.

It was computed earlier that daily calorie requirement of Indian adult man with body-weight of 55 kg, engaged in heavy manual work, was 3900 calories. This allowance does not take into consideration very heavy work under unusual conditions like army men working at high altitudes and low temperatures, where the calorie requirement may go up to 4200 calories/day. Under normal conditions, however, energy expenditure by men engaged in heavy manual labour has been shown to be within the earlier recommended allowances. Ramanamurthy and Dakshayani (1962) reported that the average energy expenditure of poor class of people, with average body-weight of 46 kg, engaged in heavy manual labour like stone cutting, was 3025 calories/day.

In another study, Ramanamurthy and Belavady (1966) reported that the daily energy expenditure of adult men (average body-weight 44 kg.), engaged in agricultural operations. involving heavy labour, was 3020 calories.

2.2. Pregnancy and Lactation :

Increased calorie requirement during pregnancy results from growth of foetus, placenta and associated tissues and increased basal metabolic rate. Dakshayani and Ramanamurthy (1964) have reported that the basal metabolic rate is increased by 5% during the first and the second trimesters and by 12% during the third trimester of pregnancy. Increased calorie requirement due to the increased basal metabolic rate will be approximately 100 calories during the latter half of pregnancy. Calories required for the increase in body-weight and for the increased energy expenditure due to heavy body-weight are estimated to be 200 calories per day. Thus the total additional need of calories during pregnancy will be 300 calories per day which should ba supplied during the latter half of pregnancy.

Increased calorie requirement during lactation is due to the increased basal metabolism and the calorie content of the milk secreted. Venkatachalam and Gopalan (1960) reported a 26% increase in the basal metabolic rate of Indian women during lactation. This corresponds to an increased daily calorie requirement of 200 calories/day. Caloric content of milk secreted per day by Indian women is about 400 calories. Assuming the efficiency of conversion of dietary calories to milk calories as 80%, additional daily calorie allowance to meet this demand is 500 calories, Thus the normal additional daily allowance of calories for Indian women during lactation will be 700 calories/day.

Calorie allowances recommended in 1958 for pregnant and lactating women, presumably engaged in sedentary work, were 2300 and 2700 calories per day respectively. It should be pointed out, however, that it is rather difficult to definc the type of daily activities of pregnant and lactating women under Indian conditions. During pregnancy and lactation, a large section of Indian women continue to do the same type of physical work as the normal women. Restriction of physical activity puring pregnancy, common among the prosperous sections of the population, is obviously not possible among the poor groups. Therefore, the calorie allowances for Indian women during pregnancy and lactation should be recommended as additional allowances of 300 and 700 calories per day, respectively, over and above their normal allowances which depend upon their daily activity.

2.3. Children :

If the calorie requirements of Indian children are calculated on the basis of actual body-weights, the requirement figures will be much lower than those recommended in 1958. These latter figures were presumably based on expected bodyweights at different ages rather than the actual body–weights of Indian children. The low body–weights of majority of Indian children are attributable to poor nutritional status. It has also been shown (Taneja, 1967) that the growth potential of Indian children is not different from that of European or American children. Threfore, the earlier recommendations of calorie allowances for normal Indian children, based on their expected body–weights, appear to be reasonable.

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3. PROTEINS

3. 1. Introduction :

Protein allowances for Indians, recommended by the Nutrition Advisory Committee of the Indian Council of Medical Research in 1944, are given in Table 1. Since then, the adult requirement was scaled down from 1.5 gm, to 1.0 gm./kg. body-weight. The considerations, which determined this revision of the adult protein allowances, have been discussed by Patwardhan (1960).

3. 2. General Considerations :

Some general considerations, bearing on the question of protein requirements, will be briefly reviewed.

3. 2. 1. Differences in Protein Needs :

The protein needs of different segments of population are obviously influenced by the physiological and the environmental factors. Protein is required by a normal adult for just maintaining the tissue integrity and making good protein loss by wear and tear (maintenance requirement), During the period of growth, protein is needed for tissue growth as well as for maintenance. During special physiological conditions, like pregnancy and lactation, extra protein is needed over and above the maintenance requirment to provide for the growth of foetus and accessory organs in pregnancy and for the secretion of milk proteins in lactation. Pathological stresses also call for extra protein intake. Unusual environment also may alter protein requirenment, but our knowledge concerning this is meagre.

3. 2. 2. *Quality of Protein*

It is well-known that the quality of dietary protein is a deciding factor in its utilization. For this reason, protein requirement naturally varies with the type of dietary protein. This would necessitate recommending dffferent protein allowances, depending upon the quality of the dietary protein. There would be as many requirement figures as are different quality proteins. To avoid this difficulty, protein requirement has been defined in terms of a reference protein which is 100% utilizable and has an amino acid pattern consistent with human requirement. Estimates of protein requirements in terms of reference protein may be converted into practical figures of protein requirement by taking into consideration the quality of protein consumed by the population.

3. 2. 3. *Influence of other Nutrients on Protein Requirement :*

In defining human protein requirement, it is tacitly assumed that the diet is adequate with respect to other nutrients. Though metabolic inter-relationship between

proteins and vitamins is known, it is not known whether dietary deficiency of vitamins influences protein requirement at all and, if so, to what extent. The position is different with regards to calories, Calories are definitely known to influence protein requirement. Obviously if the total calorie content of the diet is inadequate, protein is wasted for calorie purpose. Increasing protein in a diet deficient in calories, serves no purpose. Another relation to be borne in mind is the time relationship between the protein intake and calorie or carbohydrate intake. For best utilization, they should be consumed simultaneously.

3. 2. 4. *Pathologicul States* :

Protein requirement is affected in pathological states, especially in those conditions (burns, fever, acute infection, etc.) where there is protein catabolism. High protein and high-carbohydrate diet has been found to be beneficial, not only to prevent nitrogen loss but also for quick recovery. One condition that may be of interest in the Indian context is the possible effect of chronic undernutrition and malnutrition on protein requirements.

3. 2. 5. *Methods of determining Protein Requirement* ;

There are serveral approaches to the determination of protein requirement. An approximate assessment of protein requirement would be possible from an examination of the current protein intakes of the population groups in good health. This approach has its obvious limitations in that the protein intake of apparently healthy individuals may vary within wide limits and these figures need not necessarily indicate the physiological requirements.

Physiological requirements can be assessed by nitrogen balance studies in adult, and in infants and children by measurement of growth rates on known protein intakes,

An entirely different approach, which is widely used, is the factorial approach in which protein needs for different functions are added up to arrive at the overall protein needs. Adult protein needs, thus, are the summation of protein needs to replace obligatory protein losses in urine and feces (endogenous losses which take place even on a protein-free diet) plus the losses through sweat and shedding of hair, skin and nails. In the case of children, protein requirements, both for growth and maintenance, have to be added up. In young infants, protein allowances would include that required for chemical maturation as well. Protein requirement in pregnancy would be the sum of adult requirement in the normal state plus the requirement for growth of foetus and accessory organs. Similary the protein needs of a nursing mother are computed from adult requirement and that required for secretion of milk proteins.

3. 2. 6. *Methods of expressing Protein Requirement* :

Protein requirements have been variously expressed in terms of body-weight, body surface or as a percentage of total calories, Though body-weight is generally used as the basis for expressing protein requirements, body surface or lean body mass may be a more meaningful basis. To express protein requirements as a percentage of calories has a certain advantage since protein requirement and calories are closely related. For the proper utilization of proteins, calorie intake should be adequate. If the requirement is expressed

as a percentage of calories and if calorie requirements are met from a given diet with adequate net protein calories. protein requirements will also be met.

3.2.7. *Individual Variation* :

In defining protein needs of a population, there has to be a proper yardstick to project the figures arrived at from studies on a small group for the entire population. There is always wide individual variation in protein requirement. We do not have exact figures for this variability. Attempts have been made to use the extent of variability observed in B.M.R. studies to protein requirements. The figure of 20% has been assumed by the Food and Agriculture Organization/World Health Organization Expert Group (1965). This is, however, not based on strong evidence and is purely tentative.

Even in a given individual, requirement of protein may not be uniform at different periods and is known to be profoundly affected by stress factors including mental distress. We are ignorant of the extent of variability in protein requirement due to this factor. The Food and Agriculture Organization/World Health Organization Expert Group has arbitrarily used a figure of 10% to cover such incidental stress factors.

The foregoing discussion indicates that several factors have to be taken into consideration in arriving at the protein requirements of different population groups and in recommending protein allowances. Available data bearing on the protein requirement, obtained on Indian subjects, will now be briefly reviewed and protein allowances based on these and other data will be indicated for different groups.

3.3. Protein Requirement of Adults :

3.3.1. *Diet Surveys :*

A general idea of the protein requirements of normal Indian adults can be had from the figures for protein consumption of healthy Indian adult populations. An analysis of over 1800 diet surveys, carried out in India, reveals that protein intake may vary from 12–211 gm. (Mitra, 1953). In 61% of these surveys, which apparently covered higher income-group, the protein consumption varied from 50–100 gm. The average protein consumption in this group was 63 gm. per consumption unit, which supplied 11% of the dietary calories. These data would indicate that protein consumption of healthy population may vary between 50 and 100 gm. It is obviously difficult to decide the optimum level of protein from this wide range of intakes. However, the observation that an intake of about 50–100 gm. protein, derived mainly from vegetable source, is consistent with health, is a useful pointer.

A more satisfactory method of computing adult protein requirement is based on experimentally determined values for minimum protein requirement for maintaining nitrogen equilibrium. Minimum maintenance requirements have been mainly derived from. (*i*) nitrogen balance data, and (*ii*) endogenous nitrogen losses.

3.3.2. *Minimum Protein Required for Nitrogen Balsnce in the Adult* :

An adult can be in nitrogen equilibrium at different levels of protein intakes. However, below a certain minimum level of intake, a negative nitrogen balance ensues.

This level is taken as the minimum requirement of protein for the adult. In the usual nitrogen balance studies employed to determine this level, nitrogen losses through urine and feces only are considered. To provide for other cutaneous losses of nitrogen, additional allowance has to be made. Minimal nitrogen requirement is determined by feeding different levels of protein that results either in negative or slightly positive balance. A linear relationship usually holds good between intake and balance in this region. From this relationship, minimum protein required for nitrogen equilibrium can be calculated.

3.3.3. *Men* :

A few attempts have been made to determine experimentally the minimum protein requirement in Indian subjects. Basu and Basak (1939) investigated nitrogen metabolism in two subjects on diets in which protein was derived mainly from cereals (wheat or rice) and partly from pulses. From thirty metabolic experiments, they suggested an average minimum protein requirement figure of 46.4 gm. for a 70 kg. man.

Two studies have been carried out at the Nutrition Research Laboratories to determine the minimum protein requirement for nitrogen equilibrium in Indian subjects. Phansalkar and Patwardhan (1956) carried out nitrogen balance studies in five young men on marginal levels of protein intake (34–43 gm.) : the proteins being derived from whole egg or mixed cereals and pulses. A high degree of correlation was obtained between nitrogen intake and nitrogen balance when both the values were expressed on the basis of body surface area. The level of protein intake to maintain nitrogen equilibrium was found to be 0.5 gm. protein per kg. of body-weight per day.

3.3.4. *Women* :

Pasricha, Narasinga Rao and Gopalan (1965) studied the minimum protein requirement of normal young Indian women on diets based on rice-pulse and milk proteins. Seven volunteers were fed two or three levels of protein ranging from 19 to 31 gm. a day, so that the subjects were in negative or slightly positive balance. The diets were adequate in calories, minerals and vitamins. There was a high correlation between nitrogen intake and nitrogen balance. From this relationship, minimum protein required for nitrogen equilibrium was calculated to be 0.51 gm. protein per kg. of bodyweight. In this study, nitrogen balances in a few women belonging to the low socio–economic group and who were undernourished, were also carried out. It was found that nitrogen intake necessary for nitrogen equilibrium in these subjects was not different from those of well-to-do subjects. Values for the minimum protein required for nitrogen equilibrium for Indian subjects are shown in Table 2 and compared with data obtained from Western workers.

It can be concluded from these studies that on diets containing predominantly mixed vegetable proteins, minimum protein required for nitrogen equilibrium in an Indian adult ranges from 0.51 to 0.66 gm. with an average of 0.57 gm. per kg. bodyweight, a figure not different from the Western figures. This value does not include allowances for cutaneous losses. The minimum protein requirements of men and women, however, are not different.

TABLE 2

Minimum Adult Protein Requirement for Nitrogen Equilibrium.

Investigators		Type of protein	Minimum requirement per day	Subjects
Pasricha *et al.*	(1965)	Mixed	0.51 gm./kg. (169 gm/m^2))	Women
Basu and Basak	(1939)	Cereals & pulses	0.66 gm./kg.	Men
Phansalkar and Patwardhan	(1956)	,,	0.50 gm./kg. (22.2 gm/m^2)	,,
Hegsted *et al.*	(1946)	All vegetable	18.0 gm./m^2	Men and Women
		plus 30% meat	170 gm./m^2	,,
Bricker *et al.*	(1949)	Vegetable	18.4 gm./m^2	Women

3.4. Endogenous Nitrogen Losses :

Another approach to the computation of protein requirement of the adult is the factorial approach, where protein intake to make good the obligatory nitrogen losses through different sources, *t.e.*, urine, feces and skin, in considered. Values for protein requirements, thus obtained by the factorial method, will be in terms of a reference protein.

There is a fairly constant nitrogen loss through urine and faeces on diets containing no protein after sufficient time is allowed for the subject to adjust to this diet. When a subject is put on a protein–free diet, the urinary nitrogen drops rapidly during the firts few days and then slowly to reach an almost steady state. Nitrogen excretion at this point is taken to represent endogenous loss.

These endogenous losses through urine and feces can be determined by keeping the subjects on a protein–free diet. Urinary nitrogen loss on a protein–frce diet has been determined in a number of species and it has been pointed out that this is related to basal calories. It is generally computed that 2 mg. nitrogen is excreted per basal calorie. This figure has been generally used to compute urinary endogenous nitrogen loss from a knowledge of basal calorie expenditure.

3.4.1. *Endogenous Urinary Nitrogen* :

Some data are available for the endogenous uninary nitrogen loss on protein-free diets in Indian subjects. Basu and Basak (1939) observed in their subjects on a protein-free diet, an average urinary endogenous nitrogen excretion of 0.0385 gm./kg. Basu *et al* (1941) reported as average endogenous urinary nitrogen loss of 0.041 gm./kg. in four subjects. Karambelkar *et al.* (1950) reported an average endogenous urinary nitrogen excretion of 0.032 gm./kg. in three subjects. Mitra *et al* (1948), from their studies on six subjects, reported a figure of 0.034 gm./kg. for the endogenous urinary nitrogen

loss. Endogenous urinary nitrogen excretion has also been determined in boys (Tasker *et al* 1962) and girls (Kanta Joseph *et al.*, 1963) of 8–10 years of age. The reported figures are 1.39 and 1.23 gm. nitrogen per 24 hours in boys and girls, respectively. In these studies, basal metabolism of the subjects were not determined.

Gopalan and Narasinga Rao (1966) studied nitrogen excretion in four subjects who were kept on protein-free diet three times in each case. Average endogenous urinary nitrogen loss in these subjects was found to be 0.0372 gm./kg. Basal metabolic rate was also determined in these subjects which enabled the calculation of endogenous urinary nitrogen excretion per basal calorie, the values for which ranged from 1.30 to 1.65 mg. nitrogen per basal calorie. From the above studies it is observed that the average endogenous urinary nitrogen loss in Indians is 38 mg./kg. of body-weight or 1.5 mg. per basal calorie. This value can be employed in computing protein requirement of Indians. Western workers (Murlin *et al.*, 1946 ; Hawley *et al.*, 1948 ; Bricker and Smith, 1951) have also reported endogenous urinary nitrogen excretion of 1.3–1.4 mg. per basal calorie.

3.4.2. *Metabolic Fecal Nitrogen :*

Metabolic fecal nitrogen has also been determined by a number of workers in Indian subjects. Metabolic fecal nitrogen loss in Indian adults reported by different workers are : Basu and co-workers (1939, 1941)=1.04 gm. N/day ; Karambelkar *et al*, 1950)=0.95 gm. N/day ; Mitra *et al.* (1948)=4.96 gm. N/day ; and Gopalan and Narasinga Rao (1966)=1.07 gm. N/day. Thus, for Indian adults 1.0 gm. N/day appears to be a reasonable allowance for the endogenous fecal loss of nitrogen. Metabolic fecal nitrogen loss in Indian children of 8–10 years of age has been reported to be 0.79 per day (Tasker *et al.*, 1962 ; Kanta Joseph *et al.*, 1963). Values as high as the above figures for the metabolic fecal nitrogen loss in adults have been reported by Murlin *et al.* (1946). Bricker and Smith (1951) aud Hawley *et al*, (1948) have reported a lower figure of 0.45 for the American adult subjects. The FAO/WHO Committee (1965) on Protein Requirement have used a figure of 20 mg. N/kg. for the endogenous fecal nitrogen loss. Endogenous fecal nitrogen loss in Indians on the basis of the above data will also be about 20 mg./kg. body-weight.

The values obtained by different workers for the endogenous loss of nitrogen in urine and feces are summarised in Table 3.

TABLE 3

Endogenous Urinary and Fecal Nitrogen Excretion in Indian Adults

Investigators	Urinary Nitsogen	Fecal Nitrogen gm./day
Basu *et al*	0.041 gm./kg.	1.04
Karambelkar *et al*	0.032 gm./kg.	0.95
Mitra *et al*	0.034 gm./kg.	0.96
Gopalan and Narasinga Rao	0.037 gm./kg. (1.5 mg./cal.)	1.07
Western workers	1.3–1.4 mg./basal cal.	0.5–0 9

3.4.3. *Cutaneous Losses :*

Nitrogen losses through skin as soluble nitrogen in sweat and through shedding of integumental cells, hair and nail, can be significant. Nitrogen loss through sweat has been estimated by Mitchell and Hamilton (1949) as 0.36 gm. nitrogen per day under conditions of minimal sweating and 10 times higher under severe conditions. Integumental losses have been estimated from long-term nitrogen balance studies by Mitchell and Edman (1962) as being 0.56 gm. N/m^2 in males and 0.37 gm. N/m^2 in females. Studies carried out at the Nutrition Research Laboratories by Apte (1962) on ten subjects indicated an average nitrogen content of 30 mg./100ml. in thermal sweat when the total sweat output was 115.6 ml./hour. From these results, total daily nitrogen loss through sweat was computed as 0.318 gm./day. We do not have figures for other cutaneous losses. Gokhale (1963) estimated that sweat loss for nitrogen in Indians is about 0.5 gm./day. Our knowledge of cutaneous loss of nitrogen in Indians under different temperature and environmental conditions is incomplete. It would appear from the study reported by Consolazio *et al.* (1963) that sweat loss of nitrogen in a tropical country like India may be much higher than the above figure. These authors have reported nitrogen loss through sweat in a tropical climate ranging from 1 to 4 gm. per day. However, Ashworth and Harrower (1967) concluded from their study with acclimatised volunteers that heavy sweating under natural conditions in a tropical climate does not result in such excessive loss of nitrogen. They report that their volunteers during 6 1/2 hours work lost 3 litres of sweat containing only 0.49 gm. of nitrogen. For practical purposes, the allowance of 20 mg. N/kg. for total cutaneous losses suggested by the FAO/WHO Expert Group (1965) may be adopted for Indians, though it is largely arbitrary.

3.4.4. *Correction for Biological Value and Digestibility* :

It was pointed out earlier that the protein requirement computed from the obligatory nitrogen losses will be in terms of a reference protein. In order to convert protein requirement values, based on reference protein, to practical figures, appropriate corrections have to be be applied for the biological value (B. V) and digestibility of the dietary proteins. A knowledge of efficiency of protein utiltzation would, therefore, be necessary. Some information is available on the biological value and digestibility in adult subjects of proteins in the Indian dietaries. Biological value and digestibility coefficients of proteins in the diets used in the studies by Gopalan and Narasinga Rao (1966) were calculated. These diets were based on cereal-pulse and milk proteins. True digestibility at different levels of intake ranged from 80 to 94 (average 87.1) and true biological value ranged from 55 to 80 (average 66) with an average of 58 for net protein utilization. Several other workers also have reported values for adults ranging from 48.5 to 67 for the biological value and 62 to 97 for the digestibility coefficient (Basu and Basak, 1939 ; Basu *et al.*, 1941 ; Karambelkar *et al.*, 1951 ; Patwardhan *et al.*, 1949 ; Mitra *et al.*, 1948). These results would indicate that proteins of Indian dietaries, containg predominantly vegetable proteins, have a digestibility coefficient of 85 and biological value of 60 and net protein utilization (N.P.U.) of about 50%.

These values are for intakes higher than the minimal intake required for nitrogen equilibrium. At lower levels of protein intake, however, net protein utilization will be better than this. In normal women on marginal levels of protein intake reported by Pasricha *et al.* (1965), calculation of net protein utilization yielded an average figure of 72. Phansalkar and Patwardhan (1956) also showed that on marginal intakes, proteins derived from mixed cereals had egg replacement value of nearly 100 and those derived from wheat, 80. The results of these studies indicate that protein utilization at levels corresponding to the minimum requirement would be 70 or more. Taking all the available data together, it would appear that net utilization of proteins, of the type generally consumed by Indians, may lie anywhere between 50-80, depending upon the level of intake and the protein source. It appears, therefore, reasonable to assume a value of 65 for the net protein utilization of dietary proteins while computing the protein allowances for adults based on minimum requirement figures.

However; the net protein utilization in children who require protein intake above the maintenanee level, may be lower than 65%. Swaminathan (1963) reported net protein utilization ranging from 66–43 in children of 8–10 years of age, consuming diet containing proteins derived mainly from a single or mixed cereals and millets. Information on the net protein utilization of other vegetable protein combinations in children are not available. It can, therefore, be suggested that, for the present, a net protein utilization of 50% for the dietary protein can be employed for computing protein allowances of Indian children.

3.5. Protein Allowance for Normal Adult :

Computation of minimum protein requirement of Indian adults based on data reviewed above has been shown in Table 4. The adult protein requirement in terms of a reference protein is 0.65 gm./kg body weight, a value not very much diffierent from the figure suggested by the FAOlWHO Expert Group (1965). In arriving at this figure, allowances for stress (10%) and individual variability (20%) have been made. As discussed above a net protein utilization of 65% has been used for the proteins of Indian dietaries mainly based on a mixture of vegetable proteins in converting the requirement figures in terms of a reference protein to practical allowances. The daily protein allowance for the Indian adult thus computed is 1.0 gm. per kg. bodyweight. This is in terms of protein in the average diet of Indians.

Total daily allowance of protein for an average man weighing 55 kg. will be 55 gm. and for an average woman weighing 45 kg. will be 45 gm.

3.6. Protein Requirements in Pregnancy and Lactation :

3.6.1. *Nitrogen Balance Study in pregnancy and Lactation*:

The question of protein requirement in pregnancy and lactation has been approached through nltrogen balance studies by workers at the Nutrition Research Laboratories. Nitrogen balance studies carried out at these Laboratories in pregnancy (Jayalakshmi *et al.*, 1959) and lactation (Narasinga Rao et al; 1958) indicate that minimal protein requirement for maintaining nitrogen equilibrium may be elevated.

Pregnancy: Nitrogen balance was determined by Jayalakshmi *et al.* (1959) in eight pregnant women belonging to low socio-economic group on

TABLE 4

Com putation of Adult Protein Requirement (gm./kg./day)

Method of approach	Protein equivalent to daily nitrogen loss			Total requirement in terms of a Reference Protein *(b)*	After allowing for individual variation (20%) and stress (10%)	Practical allowance in terms of dietary protein (N.P.U. 65)
	Fecal	Urinary	Cutaneous			
Nitrogen balance	0.57[1] (0.37)[2]		0.125	0.495	0.645	1.00
Factorial Method: Indian data	0.125	0.24	0.125	0.490	0.64	0.98
Food & Agriculture Organization/ World Health Organization data	0.125	0.284	0.125	0.534	0.71	1.12

(1) In terms of dietary protein of NPU 65.
(2) In terms of reference protein.

different levels of protein intake (60-120gm.) The data are presented in Table 5. Considerable nitrogen retention was observed and the retention increased with intake upto 85 gm protein/day. A linear relationship was found between protein intake and balance below an intake of 2.8gm. protein per kg. By extrapolation minimum protein required for nitrogen equilibrium was calculated. Minimum requirement of protein in these subjects was found to be 0.9 gm,/kg/day which is about 80% higher than the minimum requirement for normal adults. Even after allowing for a higher fecal nitrogen excretion observed in these subjects, the minimum protein requirement was found to be 20-40% higher than normal.

TABLE 5

Nitrogen Balance in Pregnant Women at Different Levels of protein Intake

Subject	Term of pregnancy (weeks)	Body weight (kg.)	Nitrogen balance (gm./kg.)			
			Nitrogen intake (gm./day)			
			9.61	13.46	16.97	18.87
1	26	51.0	+2.10	+2.48	+2.73	—
2	28	35.5	+2.27	+3.96	+2.92	+3.63
3	24	35.5	+0.88	+1.63	+1.91	+2.05
4	24	49.4	+0.39	+3.77	+6.91	—
5	24	45.0	+0.17	+0.42	—	—
6	24	47.7	+1.45	+5.80	—	—
7	22	43.5	+3.41	+6.77	+8.57	—
8	26	39.9	—0.59	+3.01	—	—

TABLE 6

Nitrogen Balance in Lactating Women on Different Levels of protein Intake

Subject	State of Lactation (months)	Body-weight (kg.)	Nitrogen balance (gm./day)		
			Nitrogen intake (gm./day)		
			9.81	15.88	18.09
1	6	41.8	+0.61	+3.93	+4.54
2	9	33.6	+0.20	+1.56	+4.05
3	6	34.1	+0.24	+5.79	+5.77
4	6	38.2	+0.19	+3.25	+4.06
5	5	39.1	+0.35	+5.61	+4.93
6	13	34.1	+1.26	+4.17	+5.79

Lactation : A similar study of nitrogen balance in lactating women by Narasinga Rao *et al.* (1958) indicated a linear relationship between nitrogen balance and protein intake over a range of 60–100 gm. Nitrogen retention was observed to increase with intake upto 100 gm. protein/day. The data are presented in Table 6. Minimum protein required to maintatin nitrogen balance in these subjects was found to be 1 5 gm. protein/day/kg., which, after allowing for a high fecal nitrogen excretion observed in these subjects, was found to be 1.2 gm./kg/day. This value is about $2\frac{1}{2}$ times more than the minimal requirement of the normal adult. This requirement includes that needed for milk output also.

The subjects in these two studies had a tendency to retain considerable quantity of nitrogen, the retention increasing with intake up to a point. This probably was a reflection of their poor body protein stores, since they belonged to the low socio-economic group and can be considered to be relatively undernourished. There is definitely a need in these subjects for nitrogen retention over and above that required for meeting the maintenance and the physiological needs of lactation and pregnancy. Though some reservations have been expressed regarding the need for this extra nitrogen retention in normal individuals, advantage from such retention for the maternal tissue in undernourished women need hardly be stressed. A level of protein which results in a maximal nitrogen can be considered as their actual requirement in these subjects. Applying this criterion, protein requirement of undernourished women with bodyweight of about 40 kg. during lactation and pregnancy is found from the above studies to be 100 gm. and 85 gm./day respectively. These levels would ensure extra nitrogen retention. Since the subjects of the above studies were undernourished, daily protein requirement determined in these may not be applicable normal subjects.

3. 6. 2. *Protein Allowance during Pregnancy* :

Protein requirement in pregnancy can be computed by adding the extra protein needed for the growth of foetus in pregnancy to the adult requirement in the normal state. Long-term nitrogen balance studies by Macy and coworkers (Macy *et al.*, 1930; Macy and Hunscher, 1934) indicated nitrogen retention of the order of 200–400 gm in excess of requirement of foetus and accessory organs. Gary and Stivens (1936) ; reviewing the nutritional requirement in pregnancy, concluded that 135–145 gm. nitrogen or900–950 gm protein over and above the normal requirement is needed during pregnancy for the growth of foetus, adnexa and mammary tissue. The quantity of protein laid down during the course of pregnancy has been computed by Thomson and Hytten (1960). This is shown in Table 7. The quantities of protein laid down during different states of pregnancy as shown in Table 7 are 0.5, 3.0, 4.5, 5.7 gm. protein daily, during successive quarters of pregnancy. The growth of the products of conception and enlargement of organs of reproduction account for only about 8 kg. (or 66 %) of the actual gain in weight of 12 kg observed during pregnancy. Gain in bodyweight observed in Indian women belonging to the poor socio-economic group, during pregnancy is about 6 kg. and the birth-weights of babies born to them are also low. Even if all the weight increase is due only to the growth of foetus and enlargement of reproductive organs, total protein deposited during pregnancy in these women is much smaller than the above figure computed for well-nourished women.

The lower values for gain in bodyweight observed in pregnant women belonging to the poorer segments of population cannot be taken as representing optimum for Indian women. In the absence of reliable data on protein deposited during pregnancy in healthy well-nourished Indian women, the figures suggested for Western women may be accepted for Indian women also. On the basis of the above data additional requirement of a reference protein during the 2nd and 3rd timester to meet the demands of pregnancy will be 5.0 gm. per day. With an allowance of 20% for the individual, an extra allowance of 6.0 gm. of reference protein per day during latter half of pregnancy has been suggested by the FAO/WHO Expert Group (1965). Similar allowance can be recommended for the Indian women during pregnancy. This allowance, in terms of proteins contained in Indian dietaries with a NPU of 65%, will be 10 gm. per day. Total daily protein allowance for an average pregnant woman with bodyweight of 45 kg will be 55 gm./day.

TABLE 7

Protein laid down during pregnancy

	State of gestation (weeks)			
	10	20	30	40
Additional protein (gm.) in products of conception	2	45	220	540
Uterus and mammary glandular tissue	30	130	180	200
Maternal blood	—	60	140	200
Total	32	235	540	940

3. 6. 3. *Protein Allowance during Lactation*:

Extra protein needed during lactation can easily be calculated from the breast milk output and its protein content. Gopalan and coworkers have provided extensive data for the milk yield in lactating women belonging to the low socio-economic groups. The average milk output has been found to be 600 ml. per day with a normal protein content (1.2 gm./100 ml.) (Belavady and Gopalan, 1959). Milk output upto 800 ml. per day has been observed by these workers. The FAO/WHO Expert Group (1965) has recommended an additional allowance of 15 gm. reference protein per day assuming upper limits of milk output of 1200 ml. The optimum milk output in well nourished Indian women during lactation is not known with certainty. If an output of about 800 ml. of breast milk per day is considered optimal for a majority of Indian women, additional protein required in terms of a reference protein to compensate for the protein secreted in milk will be 10 gm. per day. On this basis the additional allowance of protein for Indian women during lactation will be 10 gm. of a

reference protein per day. This allowance, in terms of a dietary protein of NPU 65, will be 15 gm. per day. However, it is not certain whether the efficiency of utilization of dietary protein for milk protein synthesis is the same as for tissue protein synthesis. In fact it may be lower. In the absence of any reliable figure for the efficiency of conversion of dietary proteins to milk proteins, a tentative figure of 50% is suggested. If a 50% conversion efficiency is assumed, additional allowance of dietary protein during lactation for Indian women will be 20 gm. per day. Total daily allowance of protein for a lactating woman of 45 kg. body-weight will be 65 gm.

Protein allowances for Indian women during pregnancy and lactation are shown in Table 8.

TABLE 8

Suggested Allowance of Protein During Pregnancy Lactation

	Normal intake (gm.)	Additional allowance (gm.)	Total daily allowance (gm.)
Pregnancy	45	10	55
Lactation	45	20	65

Note : Pregnant and lactating women belonging to the low socio-economic group with poor body protein stores may benefit from 85 and 100 gm. protein per day.

3.7. Protein Requirements in Infancy and Childhood :

Protein allowances for infants and children should meet the requirements for growth as well as for maintenance. In the case of infants, an allowance has to be made for the chemical maturation. Nitrogen concentration of the fat free tissue increases from 2% at birth to 3% by the first year and then reaches the mature composition of 3.3% by the age of four years (Holt *et al.*, 1960). Protein requirements of infants and children can be assessed from the protein intakes which result in satisfactory growth. Alternatively this problem can be approached by measuring the protein intake for maximal nitrogen retention by carrying out nitrogen balance at different levels of intakes. The former approach has been used by several investigators (Foman and May, 1958 ; Foman, 1960 ; Omans *et al.*, 1961 ; Snyderman *et al.*, 1958) to assess the protein requirement of infants by measuring their growth on known intakes of breast-milk or cow's milk.

Experimental studies designed to determine protein requirements of Indian infants and children are extremely scanty. Gopalan (1956) studied growth of breast fed infants of Indian women, from the age of one week to twenty-two weeks and from a knowledge of the amount of milk ingested by the infant the actual protein intake at different periods was calculated. It was observed that a protein intake of 1.1 gm./kg. at sixth month and of 2.0 gm./kg. in the first fortnight was found to be adequate for a satisfactory growth as judged by the growth rate which was comparable to that of American children and by

other criteria like doubling of birthweight in four months. These data are set out in Table 9. These values are not very much different from those arrived at by the Expert Committee of the FAO/WHO which computed the protein requirements of infants based on available information on growth of infants of known intakes (vide Table 10).

TABLE 9

Intake of Protein by Breast-fed Infants

Weeks of lactation	Average weight (kg.)	Average milk yield in 24 hours (ml.)	Average protein intake per kg. of bodyweight
1	2.78	454	2.0
2	2.92	477	2.0
3	3.12	480	1.8
4	3.27	497	1.9
5	3.72	500	1.6
6	4.20	474	1.4
10	4.40	471	1.3
12	4.57	517	1.4
14	4.83	528	1.3
16	5.11	514	1.2
18	5.37	454	1.2
20	5.57	506	1.2
22	5.77	517	1.1

3.7.1. *Protein Allowance of Infants :*

Protein requirement of infants up to six months of age can be met solely by breast milk. It is suggested therefore that the protein allowance for Indian infants upto six months of age will be in terms of milk proteins on scales recommended by the FAO/WHO Expert Group. For infants between six months to one year, however, breast milk alone does not satisfy their protein needs and supplementary proteins have to be provided. The supplementary proteins for Indian infants of this age-group are most likely to be in the form of vegetable proteins. Therefore protein allowance for infants of this group can be made in terms of vegetable proteins. It should be pointed out, however, that part of their protein intake must be derived from milk.

Daily protein allowance suggested for Indian infants is given in Table 10. Since the infants are growing rapidly the allowances are given per kg. of body-weight. Actual intake should be calculated on the basis of the expected ideal body-weight of these infants at different ages.

TABLE 10

Protein Allowance for Infants

Age in months	Protein allowance (gm./kg. bodyweight)	
	FAO/WHO Figures (*a*)	Suggested for Indian infants
0-3	2.3	2.3 (a)
3-6	1.8	1.8 (a)
6-9	1.5	1.8 (b)
9-12	1.2	1.5 (b)

(a) In terms of milk protein,

(b) In terms of vegetable protein, NPU 65.

3.8. Children :

Continuous nitrogen balance determination in children upto the age of 1-10 years have been carried out by Stearns *et al.*, (1958) to arrive at their protein requirements. Such an approach has yielded comparatively high figures (3.3 gm./kg.) for the protein requirement of children. The Expert Committee of the FAO/WHO (1965) has however employed the factorial approach to calculate the protein requirement of children. Protein requirements of children above the age of one year have been computed from the obligatory nitrogen loss calculated in the same way as for adults and the protein required for satisfactory growth rate, the latter being based on the bodyweight increase and the protein component of bodyweight increase which is 18% of the weight gain. There is paucity of information which can be used to calculate the protein requirement in Indian children. Even the available information on growth rate of children pertains largely to undernourished segments and that information cannot be used to compute normal protein requirements.

3.8.1. *Protein Allowance for Children* :

Protein requirements of Indian children computed by the factorial method are given in Table 11. Values for endogenous fecal and urinary nitrogen loss per kg. of body weight determined in Indian adults and requirement for growth as employed by the FAO/WHO Committee were used in these computations. For calculating endogenous urinary nitrogen loss a figure of 1.5 mg./basal calorie has been employed since this was the value experimentally determined in Indian adults. The requirement figures thus obtained for different age-groups are in terms of a reference protein per kg. of bodyweight. To translate this into practical allowances in terms of dietary proteins, for reasons discussed earlier (vide Page 14) a value of 50% for the net protein utilization of the dietary protein in Indian children has been employed. Total daily allowances of protein per day for children of different age-groups calculated by multiplying the allowance per kg. bodyweight, by the bodyweight at different ages, has also been given in Table 11. Available

203

COMMITTEE
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data on bodyweight of Indian children pertain to undernourished population who do not exhibit full growth potential. Limited studies on growth of children in India (Taneja, 1967) indicate that well nourished children can attain bodyweights comparable to those reported for Western children. Therefore, bodyweights intermediate between the actual bodyweights and the ideal bodyweights have been employed to compute the total daily requirements of Indian children.

3.9. Protein Requirement in the Undernourished Population :

The question whether protein allowance for chronically undernourished subjects should be different from those of well-nourished individuals is often raised.

3.9.1. *Adults :*

In the case of adults studied by Pasricha *et al* (1965), it was shown that the minimum protein required for maintaining nitrogen equilibrium in well-nourished and in undernourished subjects is essentially the same. It has been demonstrated in a recent study by Gopalan and Narasinga Rao (1966) that undernourished subjects, however, have very poor body stores of labile proteins. These subjects had labile protein stores less than 1% body-weight compared to 3-5% observed in well-nourished individuals. Though the significance of labile protein stores is not clearly understood, its possible beneficial influence under conditions of stress is recognised. Population groups who are chronically undernourished with poor protein stores may need extra protein over and above the minimal needs to replenish their protein stores. A minimum intake of protein for maintaining nitrogen equilibrium would never provide them with a chance to replete their body stores of protein.

3.9.2. *Pregnancy and Lactation* :

A similar situation also exists in the case of lactating and pregnant women belonging to the low socio-economic group. They are generally grossly under-weight with poor protein reserves. This fact also was demonstrated by the nitrogen balance studies mentioned earlier (Jayalakshmi *et al.*, 1959 ; Narasinga Rao *et al.*, 1958). In these cases also there is a need for additional protein allowance for the repletion of tissue protein which would enable these women to withstand better the stress of pregnancy and lactation.

3.9.3 *Infants and Children :*

It was observed by Gopalan (1956) that though the growth rate of indian infants was comparable to that of American infants, actual body-weights of the infants studied were, however, low. Indian children of other age-groups belonging to the poorer segments of population are also underweight compared to the American counterpart. Growth performance of well-to-do Indian children has been shown to be comparable to that of Western children (Taneja, 1967). It might be argued that protein allowance for undernourished Indian infants and children, based on their actual bodyweights, may be less than that allowed for American children because of lower bodyweights of the former. Some argue that protein allowance for children, who are underweight, should be based on the ideal weight for the age rather than on the actual bodyweight, It might be expected that such an extra allowance of protein would help accelerate the growth of undernourished children. This possibility was investigated both in breast-

TABLE 11

Computation of Protein Requirement of Indian Children.

Age (years)	mg. N per kg. per day					Protein N×6.25 gm./kg.	Plus allowance for individual variation (20%) and stress (10%)	Daily allowance in terms of dietary protein (*b*)	
	Basal urinary N (*a*)	Fecal N	Cutaneous N	Growth	Total N			1 gm / kg.	Total (gm.)
Both sexes :									
1	55.5	20	20	20	115.5	0.73	0.95	1.90	16.5
2	52.5	20	20	13	105.5	0.66	0.86	1.72	18.0
3	51.0	20	20	13	104.0	0.65	0.85	1.70	20.0
4—6	49.5	20	20	13	102.6	0.64	0.83	1.66	22.0
7—9	44.3	20	20	13	97.3	0.61	0.79	1.59	33.0
10—12	40.5	20	20	10	90.5	0.57	0.74	1.48	41.0
Boys :									
13—15	37.5	20	20	10	87.5	0.55	0.72	1.44	55.0
16—19	34.5	20	20	7	81.5	0.51	0.66	1.33	60.0
Girls :									
13—15	37.0	20	20	10	87.0	0.54	0.70	1.40	50.0
16—19	36.0	20	20	3	79.0	0.49	0.64	1.27	50.0

(a) Calculated employing the relationship of 1.5 mg. N pe- basal calorie.
(b) N.P.U. of 50% was employed in calculatiug these values.

fed infants and in young childern at the Nutrition Research Laboratories. Breast fed infants of women belonging to the low socio-economic group were given extra milk so that the breast milk and supplement together provided nearly 2-2.5 gm. of protein per kg. of expected body-weight, for a period of nine months (Venkatachalam *et al.*, 1967). The growth rate and other anthropometric parameters in these children, however, were not significantly different from those of the control babies who were similarly breast fed but not given any protein supplement. In another study lasting for nine montns a group of children aged 5—10 years from a local orphanage were given a protein supplement of 18 gm, so that their total daily protein intake corresponded to the recommended allowance on the basis of the expected ideal body-weight (Darshan Singh and Swaminathan, 1966). Such a supplement did not increase their weights and heights over those of the children of the control group given placebo containing equal quantity of calories. In both these experiments, no beneficial effect of extra protein supplement was observed. These studies do not necesiarily prove that extra protein supplementation in undernourished children over

TABLE 12

Suggested Dietary Protein Allowances for Indians

Comparison of the scales of daily protein allowances as recommended by the Nutrition Advisory Committee in 1944/1958 and as revised at present.

Particulars	Recommended in		Revised
	1944	1958	
Man (55 kg.)	82 gm,	55gm.	55gm.
Woman (45kg.)	67 gm.	55 gm.	45 gm.
Woman, pregnancy	100 gm.		55 gm.
Woman, lactation	110 gm.		70 gm.
Infants 0—3 months	3.5 gm./kg.		2.3 gm./kg.
3—6 months			1.8 gm./kg.
6—9 months			1.8 gm./kg.
9–12 months			1.5 gm./kg.
Children 1 year	3.5 gm./kg.		16.5 gm.
2 years	3.5 gm./kg.		18 gm.
3 years	3.5 gm./kg.		20 gm.
4—6 years	3.5 gm./kg.		22 gm.
7—9 years	3.0 gm./kg.		33 gm.
10–12 years	3.0 gm.lkg.		41 gm.
Boys 13–15 ycars	2.5 gm./kg.		55 gm.
16-19 years	2.0 gm./kg.		60 gm.
Girls 13–15 years	2.0 gm./kg.		50 gm.
16–19 years	2.0 gm./kg.		50 gm.

and above the amount computed on the actual weight basis has no beneficial effect. Since the normal diets of these children were deficient in several other nutrients like calories, Vitamin A and calcium, beneficial effect of protein supplementation was perhaps not felt. Reduced intake of their normal diet during these supplementations may be another reason for not observing the beneficial effects of supplementation.

Dietary allowance of proteins for different groups as suggested at present has been summarised in Table 12. It will be seen that there are no alterations in allowances for adults in the levels recommended in 1958. As regards protein allowances during pregnancy and lactation the levels recommended in 1944 have been scaled down. Protein allowances for children of different age-groups have been given in terms of total daily allowance and these allowances are based on allowance per kg. of body-weight which are lower than those recommended in 1944.

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4. FAT

Next to carbohydrate, fat in the diet is an important source of food energy. Apart from being a concentrated source of energy, it serves two important functions in the diet. A certain amount of fat is necessary in the diet to help absorption of fat soluble vitamins like Vitamin A. Fats also provide the essential nutrient, the so called "essential fatty acids" or polyunsaturated fatty acids like linoleic and linolenic. These essential fatty acids are required by the body for growth and to maintain integrity of the skin. Phrynoderma, a nutritional deficiency disease of skin, is attributed partly to the dietary deficiency of essential fatty acids (Gopalan, 1947 ; Menon *et al.*, 1950). These essential fatty acids are present in vegetable oils in fairly large amounts. Animal fats are poor sources of essential fatty acids. The requirement of essential fatty acids appears to be greater in children than in adults. Apart from serving as vehicle for fat soluble vitamins and providing essential dietary factor, the polyunsaturated fatty acids, fats in the diets improve their palatability and increase gastric emptying time.

The optimum quantity of fat that has to be included in the diet is not known with certainty. At least, a minimal amount of fat should be present in the diet to provide the essential fatty acids and to facilitate absorption of fat soluble vitamins. Excess of fat on the other hand, especially the saturated fat in the diet, has been known to be undesirable. Foods, rich in fat, bring about increased blood cholesterol. Epidemiological studies indicate that hypercholesterolemia is associated with coronary heart diseases. In population groups whose diets contain fat calories to the extent 40%, hypercholesterolemia and coronary heart diseases are widely prevalent.

While a percentage of calories are derived from fat in the dietaries of the population in developed countries, the diets of the population in underdeveloped and developing countries are low in fat content, most of the calories being derived from carbohydrates. Available diet survey data in India (Visweswara Rao, 1967) have shown that in an average Indian diet, only 9-13% calories are derived from fats. Fat intake per consumption unit has been computed to be about 30 gm. Of this, visible fat in the diet is only 44%. This means that the average Indian diet contains only 13–14 gm. of visible fat. Diet survey in the children, suffering from phrynoderma, indicated that their fat intake was only 11.6 gm., of which 30% was visible fat and contained 3.2 gm. of linolenic acid (Srikantia and Belavady, 1961). The diets of these children were deficient in other B-complex vitamins as well.

Though the present knowledge does not permit fixing the dietary allowance of fat with certainty, the minimum amout of fat and the upper desirable level can be indicated. The minimum amount of fat in the diet should be such as would fulfil the two functions mentioned above, *i.e.*, providing vehicle for fat-soluble vitamins and supplying essential fatty acids. Clinical experience has indicated that 3-4 gm. fat, taken along with carotene or Vitamin A, is sufficient to ensure the absorption of the vitamin in malnourished children (Vinodini Reddy and Srikantia, 1966). It was observed by Srikantia and Belavady (1961) that a daily intake of 3 gm. or less of polyunsaturated fatty acids was associated with phrynoderma in children and that the reversal of the symptoms could be obtained by administration daily of 10 gm. of safflower oil containing 7 gm. of polyunsaturated fatty acids. From this, it can be concluded that the human requirement of essential fatty acids is around 5 gm. per day.

On this basis, it can be suggested that daily intake of 15 gm. of visible fat in the form of vegetable oils like safflower, sesame,groundnut, which contain 5-10 gm. of polyunsaturated fatty acids, appears to satisfy the minimum essential fatty acid requirement and to facilitate absorption of fat soluble vitamins. While it is comparatively easier to suggest the desirable minimum level of fat in the diet, it is rather difficult to fix thc desirable upper limit in view of the fact that the level of fat in the diet that may be harmful depends upon several factors like physical activity, polyunsaturated fatty acid content, etc. However, epidemiological data indicate that intake of fat which provides more than 40% of total calories is associated with atherosclerosis. Therefore, it can be arbitrarily suggested that it is desirable that not more than 30% of dietary calories should be derived from fat.

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5. CALCIUM

5.1. Human Calcium Requirement :

The Nutrition Advisory Committee recommended in 1944 a daily allowance of calcium as follows: 1.0 gm for adult, 1.5 gm for pregnant woman, 5.0 gm. for lactating mother and 1.0-1.5 gm for children. However, recent thinking on human calcium requirement has been that these allowances are rather high, and that levels of calcium intake of these dimensions are neither necessary nor easy to achieve in practice in countries where dietary calcium is mostly obtained from cereals and other vegetable foods and only to a limited extent from milk and milk products. Dietary intakes of calcium of the above order have been observed only in Western countries where milk and milk products contribute nearly 80% of the total calcium intake. Large sections of world's population have been living for centuries on calcium intakes much below (500 mg. or below per caput) the recommended levels and apparently no specific illeffects due to calcium deficiency have been encouuntered. Long-term balance studies (Nicholls and Nimalasuriya, 1939 : Hegsted *et al.*, 1952 ; Malm, 1958) have also indicated that calcium balance could be achieved at much lower levels (300-500 mg.) of intakes than 1 gm. calcium per day. Such balance studies (Hegsted *et al.*, 1952) in the population groups (*viz.* Peru) who are habitually consuming low levels of calcium have also yielded similar results. One interesting feature with regards to calcium is that the body can adapt to wide range of intakes remarkably well. In view of such compelling evidence, the Expert Group of the Food and Agriculture Organization/World Health Organization (1962) have recently suggested practical allowances for calcium for different groups which are nearly half of the earlier accepted values. This Group, however, felt that available data on calcium requirement were not sufficient to justify recommenation of definite figures for calcium allowances and, therefore, suggested only range of fligures. These are shown in Table 13. In recent years, the allowance of calcium has been reduced in many other countries also. Recommended adult allowances range from 0.5 to 0.8 gm. per day instead ef 1.0 gm. per day

TABLE 13

Dietary Allowance of Calcium suggested by the Expert Group of the Food and Agriculture Organization/World Health Organization.

Age-group (years)	Suggested practical allowances mg./day
0— 1	500—600
1— 9	400—500
10—15	600—700
16—19	500—600
19 +	400—500
Pregnancy and Lactation	1000—1200

5.2. Calcium Requirement of Indians :

Available information on calcium requirement of Indians is rather limited. However, data from diet survey and metabolic experiments, point out that the earlier recommended levels are high and the calcium requirement can be met by lower levels of intake.

5.2.1. *Diet Survey Data* :

Diet surveys carried out in India (Mitra, 1953) have shown that the average calcium intake is in the neighbourhood of 469 mg. per caput. More than 60% of this calcium is derived from cereals and other vegetable foods. Further, availability of calcium in such foods may be limited by associated factors like phytate, oxalic acid and high phosphorus content. Average intake of calcium of the predominantly rice eating population may be lower than the above figure. The only group which consumes a high level of dietary calcium is the one whose staple cereal is ragi which is known for its high calcium content. Though the average intake of calcium by Indians is not more than 500 mg. per day, there is no evidence of apparent ill-effects attributable to calcium deficiency. Analysis of skeletons of Indians by Shenolikar (1966) has)hown that these bones had normal calcium concentration.

5.2.2. *Metabolic Studies* :

A few calcium metabolic studies, carried out in Indian adults, also indicated that calcium balance is achieved at relatively low intakes. Basu and his co-workers (Basu *et al.*, 1939 ; Basu and Ghosh, 1947 ; Basu and De, 1948 ; Basu and Nath, 1946) have carried out calcium metabolism studies in Indian male adults on low calcium intakes roughly corresponding to intakes on their normal diets. They consider from one of theit metabolic studies that 388 mg. per day may be the maintenance requirement of calcium for Indians. From other studies of theirs, it can be seen that positive calcium balance could be achieved at intakes ranging from 177 to 485 mg./day. Cal-

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cium balance studies, carried out at the Nutrition Research Laboratories (Shenolikar, 1968) also indicated that calcium balance can be achieved in Indian subjects on low intakes. Calcium balance study was carried out in four female and three male adult subjects on intakes corresponding to their normal intakes. All the four women with calcium intakes in the range of 386-448 mg./day were in positive balance. Of the three men studied, two were in positive balance on calcium intake of 500 mg./day and one was in negative balance on a similar intake. These balance studies, notwithstanding their limitations, indicate that Indian adult can be in calcium balance on intakes ranging from 250–500 mg. Adult women appear to be better adapted to lower intakes.

One source of calcium loss from the body, which is not taken into account in balance studies, is loss through sweat. This loss has to be taken into consideration in computing calcium requirement. Apte and Shenolikar (1967) found calcium concentration in thermal sweat of Indian adult subjects to be 7 mg./100 ml. They computed the total daily loss of calcium through this source to be about 60 mg.

The FAO/WHO Committee (1962) has suggested dietary allowance of 400–500 mg. and this adults. In the light of the available data this appears to be a reasonable allowance of calcium for the Indian adult also.

5.3. Calcium Allowance in Pregnancy and Lactation

The quantity of calcium deposited in foetus has been computed to be about 30 gm. and this takes place mostly in the third trimester. This corresponds to a deposition of 300 mg. calcium per day during the third trimester. Increased calcium requirement during pregnancy is compensated by adaptation and better conservation of dietary calcium. This point is illustrated by the calcium balance study during pregnancy carried out at the Nutrition Research Laboratories (Shenolikar, 1968). Twelve expectant mothers were subjects for this study. Calcium balance was determined during three trimesters in these subjects on intakes ranging from 420 to 457 mg./day calcium, a level of intake which they were accustomed to. On these intakes, six subjects were in positive balance and six subjects were in negative balance during the first trimester. However, in the second and in the third trimesters all the subjects were in positive balance on the same intakes. This study would appear to indicate that on a given calcium intake, body tries to conserve dietary calcium during pregnancy.

During lactation, calcium drain from the body is somewhat more. Normally 200–300 gm. of calcium is computed to be secreted through milk. Studies by Belavady and Gopalan (1959) indicate that nursing mothers, belonging to the low socio-economic group, secrete on the average 200 mg. calcium a day (30–41 ml/100 ml–600 ml. milk) in breast-milk.

It would appear, therefore, that an additional intake of calcium, to result in a retention of about 300 mg. calcium/day, is necessary during pregnancy and lactation. The level of calcium intake, which would result in such retention, is not known exactly in normal Indian women during pregnancy and lactation. Taking into consideration wide individual variations in absorption and retention of dietary calcium, an intake of gm. of calcium may be expected to cover the calcium needs in pregnancy and lactation.

5. 4. *Infancy and Childhood :*

Calcium requirements in early infancy can be computed from calcium intakes through breast-milk of healthy infants solely breast-fed. On this basis, up to six months of age calcium intakes of about 300 mg. would satisfy their needs. The FAO/WHO Expert Group have suggested an intake of 500–600 mg. calcium a day for infants up to the age of one year when artificially fed.

Calcium requirement during growth can be computed either by balance studies or by considering the amount of calcium acretion during he periods of growth. The latter is calculated from the calcium content of body at birth and at adulthood. At birth, foetus contains 20–35 gm. of calcium, and a body of an adult weighing 50–70 kg. contains 850–1400 gm. calcium. This amount of calcium, i. e. 1200 gm. deposited over a period of twenty years, corresponds to a daily average calcium retention of 165 mg./day. Skeletons of cadavers of Indian adults, analysed by Shenolikar (1966), have been shown to have normal concentration of calcium . The total skeletal calcium (99% of body calcium) was found to be 671 gm. for females and 682 gm. for males. The lower figures may be a reflection of lower body size of these subjects.

Diet surveys indicate that the average daily calcium intake of children in India is 300 mg. or less. However, Kurian et al. (1961) have shown that children (10–11 years) can be in positive calcium balance of 120 mg./day even on low intakes of 354 mg. per day. The diet survey data would indicate that calcium intakes of Indian children are sub-normal and the stature and growth of these children also are substandard. Attempts to demonstrate that sub-normal growth of Indian children is due to low calcium intakes have not yielded conclusive results. Aykroyd and Krishnan (1938, 1939) demonstrated that calcium lactate supplementation (0.5-1.0 gm./day) to group of children aged $2\frac{1}{2}$-7 years, with sub-normal dietary calcium intakes of 310 mg. a day, resulted in an improved growth. However, in a recent study by Bhansal et al. (1964) at the Nutrition Research Laboratories, supplementation of calcium glycerophosphate (2.5 gm. to children below 1 year and 5 gm. for those above 1 year) for a period of fortytwo weeks to a group of children of 6-30 months in a rural community, with calcium intakes of 178-85 mg./day, on their usual diets, did not bring about any improvement in growth. These studies thus leave the question of calcium requirement of Indian children still open.

In the absence of any definitive data on calcium requirement of Indian children of different age-groups, the suggested allowances of dietary calcium by the FAO/WHO Expert Group can be adopted for Indian children for the present.

A brief review of available studies bearing on the calcium requirements of Indians indicates that there are not sufficient data to make specific recommendation of calcium allowance for Indians. However, these data suggest that considerations, viz low intakes, adaptation to low intakes and absence of specific calcium deficiency states, which prompted the Expert Group of the FAO/WHO to lower the level of conventional calcium allowance, also apply to situation that exists in India. Therefore, the practical allowance of calcium suggested by the FAO/WHO Expert Group can be adopted for Indians also

In the case of pregnancy and lactation, however, an intake of 1000 mg. has been suggested. Suggested dietary allowances of calcium are shown in Table 13*a*.

TABLE 13a.

Suggested Dietary Allowance of Calcium for Indians

Age-group		Calcium allowanee (mg./day)
Adult	Man Woman ...	400—500
Pregnancy and Lactation	...	1000
Children 0—12 months		500—600*
1— 9 years		400—500
10—15 years		600—700
15—19 years		500—600

*Applies to artificially fed infants. Breast-fed infants need no additional supplement.

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6. IRON

6.1. Introduction :

The question of iron requirement assumes special significance in the context of widespread prevalence of iron deficiency anaemia in India. Nutrition Surveys, carried out by the Nutrition Research Laboratories and others, indicate that about 20% of the Indian population suffer from iron deficiency anaemia. This incidence is even higher among women of child-bearing age. This situation exists with seemingly satisfactory intake of dietary iron as revealed by diet surveys.

The Nutrition Advisory Committee recommended, in 1944, dietary allowance of iron for adults : 20-30 mg. and for children 10-30 mg. Separate allowance figures were not given for different age-groups and for different physiological states like pregnancy. A re-evaluation of dietary allowances of iron for Indians becomes necessary in the light of considerable amount of research on iron metabolism and iron requirement in Indians, done during the last decade.

6.2. Human Requirement of Iron :

Iron allowance for an adult, adopted by different countries, ranges from 6 to 15 mg. per day. The National Research Council of U.S.A, (1964) has recommended the following dietary allowances of iron (mg./day) : adult men, 10; adult women, 15 ; pregnancy and lactation, 20; infants, 1 mg./kg ; children, 8-15. Dietary allowances of iron recommended by the National Research Council of U.S.A. and other bodies are shown in Table 14. These allowances seem to be adequate in temperate climates and when the dietary iron is present in easily assimilable form. However, in a tropical country like India, iron losses are likely to be greater and the iron is mainly derived from cereals and other vegetable foods which contain factors like phytates, phosphates which interfere with iron absorption. These dietaries are also deficient in factors like ascorbic acid which facilitate iron absorption. These factors have to be taken into consideration in evaluating iron needs of the Indian population.

Iron requirements of different groups are computed mainly by the factorial approach. Iron requirement is equated to iron lost through urine, sweat and blood. Dietary iron intake to replace these losses is computed after taking into consideration the extent of absorpition of food iron. Iron absorption is physiologically regulated and is influenced by a variety of dietary factors. Iron requirement during growing period is computed by taking into consideration iron losses and increase in body iron that takes place during growth. Body iron in an adult ranges from 2 to 4 gm., of which 70% is

haemoglobin iron, 15% functional tissue iron and 16% storage iron. Body iron content of infant at birth is about 0.27 gm.

TABLE 14

Dietary Allowance of Iron Recommended by Different Organizations (mg./day)

Group	Indian Council of Medical Research (1944)	British Medical Association (1950)	World Health Organization (1959)	National Research Council of U.S.A. (1964)	American Medical Association (1966)
Men	20-30	12	10	10	10
Menstruating women		12	12	15	20
Pregnant women		15	15	20	35
Lactating women		15	15	20	—
Adolescent girls	10-30	15	15	16	12-25
Adolescent boys		15	15	15	—
Infants and children		7-3	5-12	10-15	10

6.3. Iron Requirement of Indians :

Research carried out on several aspects of iron requirement of Indians will be briefly reviewed.

6.3.1. *Intake of Dietary Iron by Indians* :

Results of diet surveys in India (Ramalingaswami and Patwardhan, 1949; Mitra, 1953) indicate that the average intake of iron is 30 mg. per day per consumption unit, the range being 6 to 109 mg. Diet survey results suggest that 6% of the average families studied had dietary iron intakes less than 15 mg., and 10% less than 20 mg. To this, one should add iron derived from cooking vessels. Studies at the National Institute of Nutrition ries have shown that a significant amount of iron can be derived from this source. Notwithstanding the uncertainties of iron intake figures obtained from diet surveys, it is evident that the average dietary intake of iron by Indians is by no means low. It is surprising, therefore, that iron deficiency anaemia should be so widely prevalent. It is possible that the intake of iron by the anaemia subjects may be marginal. Indeed the results of duplicate meal analysis of diets of anaemic subjects, carried out at the National Institute of Nutrition have shown that nearly half the subjects had marginal or low intakes while the other half had intakes which were quite high compared to the Western recommended allowances. It would, therefore, appear that there are other factors like poor absorption of dietary iron or excessive loss of body iron operating under these conditions.

6.3.2. *Iron Absorption* :

Several iron balance studies in healthy Indian adults, consuming different types of diets, have been carried out employing chemical balance method. Apart from determining iron absorption from these diets, effects of phytate, calcium and ascorbic acid on absorption of iron from the above dietaries have also been determined. De (1950) reported that the iron retention was 5.86 mg. when iron intake was 24.84 mg. It was observed by Hussain and Patwardhan (1959*a*) that 20% of iron was absorbed from a well-balanced diet based on rice or wheat containing 38.44 mg. iron. Cereals, which form a major part of the Indian dietaries, contain phytate which interferes with iron absorption. Hussain and Patwardhan (1959*a*) have shown that in balanced diets containing 8 and 40% phytate, iron absorption was markedly reduced to 11 and 3% respectively. In another experiment, Apte and Venkatachalam (1962*a*) showed that an intake of about 20 mg. of dietary iron was necessary to result in any significant absorption of iron when the diet contained cereals with 40% phytate. It is known that dietary calcium combines with phytate. It was shown by Apte and Venkatachalam (1964) that the iron absorption from diets, containing phytate, could be increased by increasing the dietary calcium. Iron absorption from such a diet, containing 1500 mg. calcium, was found to be maximal. Ascorbic acid also has been shown to improve iron absorption by these workers (Apte and Venkatachalam, 1965). It would appear from these studies that though iron absorption is decreased by phytate present in cereals and other foods, liberal amounts of calcium and ascorbic acid in the diet seem to counteract the phytate effect. However, diets of poorer segments of population in India not only are rich in cereals containing phytates but are poor in calcium and ascorbic acid and hence iron absorption may be expected to be poor on these diets. Chemical balance studies, employing such diets, gave values for iron absorption ranging from 7% to 28% with an average of 13% (Apte and Venkatachalam, 1965).

From all the available data on iron absorption, it can be suggested that a value of 10% may be used for computing the absorption of iron contained in an average Indian diet while making dietary allowance of iron for Indians.

6.3.3. *Iron Losses* :

In arriving at the human iron requirements, iron excretion from the body through different routes has to be considered. Major routes of iron losses are *(i)* haemoglobin iron loss through haemorrhage : *(ii)* iron excretion through urine, sweat and bile; and *(iii)* desquamation of iron containing cells from the gastro-intestinal tract and skin.

Urinary output of iron has been estimated to be 0-1 mg. or less per day. Gastro-intestinal loss of iron has been estimated to be 0.2-0.5 mg. by different workers (Ingalls and Johnston, 1954; Dubach *et al.*, 1955). Dermal losses may be an important source of iron loss in tropics. Hussain *et al.* (1959*b*), 1960) and later Apte and Venkatachalam (1962*b*) and Apte (1963) carried out several studies to assess the dermal loss of iron in Indians. In these studies, it was observed that dermal loss of iron in the volunteers studied varied from

0.58 to 3.22 mg./day. On the basis of these results, it was suggested that non-haemoglobin loss of iron in Indians is probably in the range of 0.8-2.6 mg./ day, with an average of 1.7 mg./day. If a 20% allowance is made for individual variability, body requirement of absorbed iron for an adult, to replace iron losses, will be 2.0 mg. per day. This, in terms of dietary iron, will be 20 mg./day. To this figure should be added loss of haemoglobin iron during menstruation in women. Apte and Venkatachalam (1963) determined menstrual loss of iron in Indian women. This loss was shown to be 8 to 30 mg. per period, or 0.3 to 1.0 mg. of iron per day with an average of 0.5 mg./day. Taking the upper limit of 1 mg. iron per day lost through this source, an additional 1 mg. of absorbed iron should be provided for menstruating women. Total requirement of absorbed iron by women who are menstruating will then be 3 mg. per day. This allowance in terms of dietary iron will be 30 mg./day.

6.4. Pregnancy and Lactation.

Iron requirements during pregnancy and lactation are increased. Extra iron is needed during pregnancy for the foetus and to replace iron lost during parturition. During lactation, additional iron is needed to provide for the iron secreted in breast-milk. Apte and Venkatachalam (1963) measured iron loss during parturition in twelve subjects. On the basis of these results, a Balance Sheet of extra iron demand during pregnancy was constructed. It was estimated that an average additional demand of iron of 150 mg. exists during pregnancy. These values are lower than the figure of 320 mg. iron given by the Western workers. Based on these results, iron loss during pregnancy can be computed to range from 0.5 to 3.5 mg./day, with an average of 1.5 mg. If a 20% allowance is made for individual variability, extra absorbed iron required during pregnancy will be 1.8 mg./ day. Total daily requirement of absorbed iron during pregnancy will then be 3.8 mg./day. In terms of dietary iron, daily allowance for pregnant women will be 38 or 40 mg. iron. Iron balance study, carried out recently in pregnant women during the three trimesters by Apte and Leela Iyengar (1968), also confirms that an intake of about 40 mg. of dietary iron per day is necessary to meet the total iron demands during pregnancy.

Belavady and Gopalan (1959) have reported that mature breast-milk contains 0.12 mg. iron per 100 ml., with milk yield ranging from 400 to 800 ml. Iron loss during lactation through milk in Indian women belonging to the lower socio-ecomic group will be 0.48-0.96 mg. per day. Iron loss during lactation amounts to 1.0 mg./day if the upper limit of milk secretion is considered. Additional requirement during lactation will then be 1 mg. absorbed iron per day. Total requirement of absorbed iron during lactation amounts to 3 mg./day. Dietary allowance of 30 mg. iron per day can, therefore, be suggested for Indian women during lactation. If the lactating woman is also menstruating, the allowance has to be little higher. An allowance of 35 mg. can be suggested in the latter case.

6.5. Infants and Children.

Total iron requirement druing infancy is considered to be about 0.8 mg. per day. Allowing for 10% absorption, an intake of 8 to 10 mg. per day can be considered to be adequate. This works out to be about 1.0 mg./kg.

Iron requirement for growth varies at different periods of infancy and childhood but is maximum in infancy and adolescent period. If one assumes that the normal infant at birth has 300 mg. of total body iron and the adult body has about 4 gm. of iron, then the average amount of iron required for growth and development is about 240 mg./year or 0.6 mg./day. Loss of iron in children through other sources is not known exactly. It is estimated that an intake of 10–15 mg. of dietary iron per day is expected to cover iron requirement for growth and to replace iron loss through defferent routes in children. Based on iron losses from body, iron requirements of adolescent boys and girls may be expected to correspond to those of adult man and woman respectively. It is recognised, however, that during adolescence some additional iron is required for the adolescent growth, though the extent of this increased requirement is not known. Therefore, while recommending dietary allowances of iron, the scales of allowances for the adolescent boys and girls should be placed higher than those for the adult men and women respectively.

6.6. Dietary Allowance of Iron for Indians :

Iron losses and extra iron requirements of different groups have been tabulatcd (Table 15). The suggested iron intakes, to cover these requirements, have also been

TABLE 15

Iron Requirement and Suggested Dietary Allowances for Indians (mg./day)

Group	Absorbed iron required					Suggested dietary allowance
	Urine, Sweat and feces	Menses	Milk	Pregnancy	Total	
Men and Post-meno Women	2.0	—	—	—	2.0	20
Menstruating women	2.0	1.0	—	—	3.0	30
Pregnancy	2.0	—	—	1.9	3.8	40
Lactation	2.0	—	1.0	—	3.0	30 *a*
Adolescent girls	2.0	1.0	—	—	3.0	35 *b*
Adolescent boys	2.0	—	—	—	2.0	25 *b*
Children	—	—	—	—	—	15–20
Infants	—	—	—	—	—	1.0 mg/kg.

(a) If the lactating woman is also menstruating, allowance may be raised to 35 mg-
(b) Additional 5 mg. for adolescent growth.

incorporated in this table. A 10% absorption has been assumed in arriving at the dietary allowance.

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7. VITAMINS

7.1. Introduction :

The Nutrition Advisory Committee recommended dietary allowances (Table 1) of thiamine, Vitamin A, ascorbic acid and Vitamin D for Indians, in 1944, but made no recommendations regarding the dietary allowances of riboflavin and nicotinic acid since it was felt that sufficient information was not available.

7.2. Vitamin Allowances Recommended by other National and International Nutrition Advisory Bodies :

When the latest available recommendations of vitamin allowances for the adult adopted by different countries (*vide* National Research Council of U.S.A., 1964) and by the Expert Group of FAO/WHO (1967) are compared it is seen that, except for vitamin A and ascorbic acid, recommended allowances by different countries are within a narrow range. Vitamin A allowances range from 2000 I.U. to 5000 I.U./day while allowances for Vitamin C range from 20 to 70 mg./day. Thiamine allowances vary from 1.2 to 1.6 mg./day for males and 0.7 to 1.4 mg./day for females. Riboflavin allowances lie between 1.4 to 1.8 mg./day for males and 1.1 to 1.5 mg./day for females. Niacin allowances, which are considered together with tryptophan, range between 12-21 mg./day for males and 10-15 mg./day for females. In the recommendations by the National Research Council of U.S.A. (1964), which have been revised from time to time, there has been no recent change in the allowances for Vitamin A, ascorbic acid and niacin, but thiamine and riboflavin allowances have been slightly reduced. The recent recommendations of FAO/WHO (1967) with respect to thiamine, riboflavin and niacin requirements, which have been considered in relation to calorie intake, are similar to those adopted by other countries. The recommended allowances for Vitamin A, however, are lower : 750 μg. (2250 I.U.), when the dietary source is retinol, or 4500 μg. when the source is entirely β-carotene. Dietary allowances of vitamins, as suggested by the FAO/WHO Expert Group, are shown in Table 16.

TABLE 16

Daily Intakes of Thiamine, Riboflavin, Niacin and Vitamin A, as Recommended by the FAO/WHO Expert Group (1967)

Age	Thiamine (mg.)	Ribo flavin (mg.)	Niacin equivalents (mg.)	Vitamin A (retinol) (μg.)
Infants				
0-3 months	—	—	—	
4-6 „	—	—	—	
7-12 „	0.4	0.6	6.6	300
Children				
1 year	0.5	0.6	7.6	250
2 years	0.5	0.7	8.6	250
3 years	0.6	0.8	9.6	250
4-6 years	0.7	0.9	11.2	300
7-9 years	0.8	1.2	13.9	400
10-12 years	1.0	1.4	16.5	575
Adolescents				
13-15 years				
Boys	1.2	1.7	20.4	725
Girls	1.0	1.4	17.2	
16-19 years				
Boys	1.4	2.0	23.8	750
Girls	1.0	1.3	15.8	
Adults				
Man	1.3	1.8	21.1	750
Woman	0.9	1.3	15.2	
Pregnancy				750
Lactation	1.3	1.9	21.8	1200

7.3. General Considerations :

7.3.1. *Methods employed in assessing human vitamin requirements* :

Those based on dietary intakes : One of the rough methods of arriving at the vitamin requirements is to consider the intakes of well-nourished and healthy population groups. Such intake values would, however, show a wide range and would not give an idea of the minimum or perhaps even the optimum requirement of these vitamins. Often, these values are likely to represent the upper limits. The minimum intake of these vitamins, consistent with good health, can be obtained by a careful study of dietary intakes of several healthy population groups with varying levels of intakes. Information as to the levels of intake, which are below the requirement levels, can be obtained from the data on dietary intakes of population groups in whom clinical evidence of the concerned vitamin deficiencies are widely prevalent. To obtain such information, simultaneous diet surveys and nutrition surveys of the same population groups are essential. Diet surveys of the patients suffering from actual clinical signs of the vitamin deficiencies will also yield information on the levels of intakes which are obviously below the minimum requirement.

Human depletion studies : The minimum requirement of vitamins can be assessed from long-term depletion studies in human subjects. After depletion and inducing deficiency signs, minimum intakes needed to reverse the signs or minimal intakes needed to prevent appearance of such deficiency symptoms may yield information on the minimal requirements. Information on the minimum requirement can also be obtained in clinical studies with patients by determining the minimum amount of the vitamin required to cure the clinical symptoms of vitamin deficiency. Such studies, though precise, are time-consuming and difficult to perform. However, several such studies to determine requirement of Vitamin C, Vitamin A, riboflavin and thiamine, have been conducted. These types of studies yield information on the minimal requirements of the vitamins, but do not give any idea of the optimum intakes which will provide for tissue saturation in case of water soluble vitamins or which may provide for reasonable liver storage in the case of fat soluble vitamins.

Studies based on turnover of vitamins : The minimal requirement of a vitamin can be considered to be that level of intake which would replace the inevitable losses of the vitamins in the body due to metabolism and excretion. Such losses have been determined by turnover studies employing vitamins labelled with radioactive isotopes. This approach has been used to determine the minimum requirement of Vitamin B_{12}. Urinary excretion alone of vitamins would not yield information on daily turnover, because some of the vitamins may be lost through sweat and bile, or part of it may be oxidized to CO_2 or converted into other metabolic end-products. There are still lacunae in our knowledge regarding the end-products of metabolism of several vitamins. Estimation of these end-products in urine also presents difficulties. This approach, however, has been employed to assess the requirement of thiamine by determining the urinary excretion of metabolites of pyrimidine and thiazole moieties of thiamine. It should be remembered, however, that turnover of any vitamin is related to the body stores of that vitamin. The level of dietary

intake of any vitamin would, therefore, depend upon the level of tissue saturation required to be maintained. Levels of intake to maintain the tissue fully saturated will be several times more than the minimum levels.

Urinary excretion and tissue levels as related to intake: Studies on urinary excretion of vitamins at varying levels of intakes have also been employed to arrive at the minimum requirement. In many instances, urinary excretion increases proportionately with increased intake only above a minimal level of intake. For a long time, vitamin requirements (optimum) have been determined by urinary excretion studies on different levels of intake and return of a test dose of the vitamin. On intakes which provide for full saturation of tissues, return of a test dose would be very high. This approach would not be feasible in all cases, *e.g.*, with fat soluble vitamins and vitamins (*viz.* thiamine), a considerable proportion of which is metabolized to end-products before excretion. Optimum requirement of vitamins, like Vitamin C, has also been assessed by determining the level of intake which results in a maximal concentration in a tissue like WBC.

7.3.2. *Minimal and optimum intake* :

The foregoing discussion indicates that vitamin intakes, satisfying the minimum requirement, would prevent development of deficiency symptoms but would not provide for any body reserve which can be utilized during stress including periods of deprivation. Optimum intakes, on the other hand, would provide for tissue saturation and adequate stores, However, the optimum levels of intake for tissue saturation in the case of water soluble vitamins, or for liver storage in the case of fat soluble vitamins, are still a matter of speculation.

7.3.3. *Factors influencing vitamin requirements* :

The requirement of vitamins as well as that of other nutrients would be influenced by several physiological factors. Thus, during physiological stress conditions like pregnancy and lactation, additional vitamin intake over and above the normal requirement would be necessary to provide for the needs of the growing foetus during pregnancy and for the secretion of milk during lactation.

Pathological conditions may be expected to increase the vitamin needs, though clear-cut evidence for such an increased requirement is still lacking in the case of several vitamins.

Since many of the water soluble vitamins belonging to the B-group participate in the metabolism of major nutrients like fats, carbohydrates and proteins, their requirement may be influenced by the levels of intake of these nutrients. The relationship between thiamine requirement and carbohydrate calories of the diet is well-known. Riboflavin and niacin requirements are shown to be related to the protein content of the diet. Since the vitamins of the B-group participate also in energy metabolism, their requirement will be related to calorie intake. Environmental, physiological and pathological conditions, which alter calorie requirement, can be expected to alter the requirement of these vitamins.

The B-group vitamins are synthesized by the intestinal micro-organisms and at least part of these vitamins is known to be available to the host. Dietary factors which

influence the intestinal synthesis of the vitamins (*viz.*- type of carbohydrate) may also modify the dietary requirement of these vitamins.

7.4. Vitamin Requirement and Recommended Allowances :

Physiological requirment of any nutrient is usually determined from the observations made on a small group of subjects. While recommending dietary allowance for the population based on physiological requirements, several factors have to be taken into consideration.

7.4.1. *Individual variability* :

While translating the physiological requirements of nutrients to practical allowances for the entire population, one important factor that has to be taken into consideration is the individual variability. Hence necessary allowance for individual variation in the vitamin requirement has to be made. Based on variation, one observes in BMR of a large population, a 20% allowance has been suggested to cover individual variation. Allowance for individual variability needs to be made only in the case of water soluble vitamins which are not stored in the body to any significant extent. Such allowances are not necessary in the case of vitamins like fat soluble vitamins which can be stored adequately in the liver.

7.4.2. *Availability* :

The biological availabilitv of vitamins, present in the foods, is another important factor that has to be considered in arriving at the vitamin allowances. Since the availability may differ from one food to another, the nature of the dietaries of the population should be taken into account in making practical allowances. It can be safely said that our knowledge in this area is very scanty except perhaps in the case of β-carotene. At least in the case of β-carotene it has been shown that there is considerable variation in its availability from different sources. Availability of carotenes from different foods is an important factor in any consideration of Vitamin A allowance for Indians since their dietary source of vitamin is largely carotene derived from vegetables. This is especially true of the poorer segment of Indian population.

7.4.3. *Cooking losses* :

Another practical consideration in recommending vitamin allowances for different population group is the loss of these vitamins during cooking. Many of the vitamins are susceptible to destruction during cooking. Hence the dietary and cooking habits of the populatien will determine the extent of actual availability of vitamins present in raw foods. Proper allowance has, therefore, to be given for such losses in making practical recommendations since computations of dietary intakes of vitamins in these population groups are usually based on the vitamin content of raw foods. This factor is particularly important in considering the vitamin requirements of Indians since there is considerable loss of vitamins, especially of thiamine, of Vitamin C, from foods during cooking as practised in Indian homes. Vitamin C in Indian dietaries, for example, is derived mainly from cooked foods rather than from fresh vegetables and fruits. Hence allowance for cooking losses has necessarily to be made.

7.5. Vitamin intakes of Indians as revealed by diet surveys :

Numerous diet surveys have been carried out in different parts of India over the past several decades. Unfortunately, data on intakes of various vitamins as revealed by

these diet surveys, have not yet been systematically processed as has been done in the case of calories and proteins. Data on intakes of vitamins, calculated from these surveys, are less reliable than those pertaining to the intake of proximate principles. It is not possible on the basis of the available information on the vitamin intakes of different economic groups to attempt a correlation of intakes with the vitamin nutrition status of these groups. Specific data about intakes, which have a bearing on vitamin requirements, will be discussed under respective vitamins.

7.6. **Vitamin A** :

Though Vitamin A requirement in relation to its function in the visual process is fairly well-understood, body needs of this vitamin for several of its other functions in human subject like growth, mucopolysaccharide metabolism, etc., are not yet clearly known.

7.6.1. *Human requirement of Vitamin A* :

Several controlled human studies (Medical Research Council, 1949; Moore, 1957), involving Vitamin A deprivation, have indicated that a daily intake of 390 μg. retinol (6 μg/kg. of body-weight) is sufficient to correct impaired dark adaptation. Several animal studies (Guilbert *et al.*, 1937, 1940) also indicate a minimum requirement of 4-6 μg./kg. for dark adaptation. Obviously, on these intakes, significant liver storage or satisfactory serum levels cannot be expected. In the Sheffield Study (Medical Research Council, 1949) it was observed that an intake of 750 μg. retinol per day for 14 to 17 months was able to maintain serum Vitamin A level constant and prevent impairment of dark adaptation. It is not, however, certain whether this intake provided for liver storage also. It is well recognised that serum levels do not reflect liver storage, and serum levels can be maintained at the expense of liver stores. Based on these data, the FAO/WHO Expert Group (1967) has concluded that 750 μg. (or 2500 I.U.) or 12 μg./kg. retinol is the Vitamin A requirement of an adult. The basis for expressing Vitamin A requirement in relation to body-weight is, however, not clear. So far as pro-vitamin A, β-carotene, is concerned, the FAO/WHO Expert Group has assumed that 1 μg. β-carotene has biological potency of only 0.167 μg. of retinol. This is based on the fact that the theoretical efficiency of conversion of β-carotene to retinol is 50%, and that the absorption of β-carotene from foods is only about 33%. On this basis, if the dietary source of Vitamin A is solely β-carotene, the daily requirement would be 4500 μg. β-carotene.

7.6.2. *Vitamin A Requirement of Indians* :

Diet Survey Data : A survey by Aykroyd and Krishnan (1936) of 436 children between ages 1-12 years, in a labour camp, indicated Vitamin A deficiency of 27 % among them. An estimate of dietary intake of Vitamin A, which was entirely in the form of carotenes, indicated intakes of 454, 709, and 785 μg. carotene by the children in the age-groups 1-5, 5-8, and 8-12 years, respectively. This study showed that the above intake of carotene was sub-optimal for those children.

Gilroy (1951) has reported from his survey of children in the tea estates of Assam that their Vitamin A intake was low and the incidence of xeropthalmia among them high. It was observed by him that the daily supplementation of 3000

I. U. of Vitamin A for seven days, while decreasing the severity, did not cure xeropthalmia completely. Clinical observations by workers in the National Institute of Nutrition (unpublished) indicate that the administration of 4000-5000 I. U. of Vitamin A per day can clear up Bitot Spot and cure night-blindness in children in a week's time. Family and institutional diet surveys, carried out by Ahmed and Gore (1940) in Calcutta, indicated that with a daily Vitamin A intake of 141 μg. in the form of retinol and 10.9 mg. in the form of carotenes, no evidence of Vitamin A deficiency was seen in the group surveyed. This finding would indicate that a daily intake of 10 mg. carotene represents an adequate level. However. diet surveys, carried out by the National Institure of Nutrition (Prahlad Rao *et al*, unpublished). indicate that Vitamin A intake of children of the low socio-economic group is 250-300 I. U. (100-150 I, U. preformed) and of the pre-school children 381 I. U. These intakes are below requirement levels since incidence of Vitamin A deficiency in this population group was high and the Vitamin A content of serum of these subjects was also less than 32 I. U. per 100 ml., compared to 80 I.U./100 ml. serum found in normal children.

7.6.3. Dark Adaptation Studies on Vitamin requirement of Indians :

Basu and De (1941) studied dark adaptation in relation to Vitamin A intake in a rather detailed manner. Employing a modified biophotometer, dark adaptation was tested in 351 subjects; and they obtained threshold values of 80 units for boys and 70-80 units for adults, which were taken as normal values. Several subjects were saturated with Vitamin A till their threshold values reached a study state. Minimum intake to maintain these values was then determined. These authors concluded that daily Vitamin A intake of 4000 I. U. (1300 μg.) for boys and 3000 I. U. (1000 μg.) for adults was necessary to maintain normal dark adaptation. It should be admitted that dark adaptation test and criteria employed are somewhat empirical and suffer from subjective errors. Therefore, Vitamin A requirement figures obtained by this method have to be accepted with some reservation. These values are clearly higher than the minimal requirement figure of 750 μg. retinol suggested by the FAO/WHO Expert Group. In the absence of more satisfactory data on Vitamin A requirement of Indian adults, the dietary allowance of 750 μg. retinol/day suggested by the FAO/WHO Expert Group for the adult can be accepted for the present.

7.6.4. Pregnancy :

Vitamin A nutritional status of pregnant women has been studied by Venkatachalam *et al.* (1962). Serum Vitamin A and carotene in fifty-three apparently normal pregnent women, belonging to the low socio-economic group, were determined in different trimesters. These women, whose daily Vitamin A intake ranged between 600-800 I. U., had subnormal levels of serum Vitamin A (64 I. U./100 ml.), indicating poor Vitamin-A nutritional status. Neonates, born to some of these women, were found to have 49 I. U./100 ml. serum Vitamin A. However, the neonates whose mothers were supplemented daily with 10,000 I. U. of Vitamin A during the last trimester showed significantly higher serum Vitamin A (89 I. U./100 ml.). These studies indicated that Vitamin A nutritional status of expectant mothers of the poorer segments of population is unsatisfactory and

this may play a part in the etiology and pathogenesis of Vitamin A deficiency in children born to them.

The FAO/WHO Committee (1967), based on the Vitamin A content of the new-born (5400–7200 μg. or 45 μg per gm.), has calculated an additional daily intake of only 25 μg. retinol for this purpose. It is not certain, however, whether extra Vitamin A is needed for functions other than meeting the foetal needs. Since extra intake of Vitamin A to meet the foetal needs is small, the FAO/WHO Expert Group did not recommend any additional allowance during pregnancy. The National Research Council of U. S. A. has recommended an additional intake of 1000 I.U./day.

7.6.5. Lactation :

Extensive studies (Belavady and Gopalan, 1959) on breast-milk output and its composition have indicated that women belonging to the low socio-economic group put out daily about 420 I. U. of Vitamin A in milk. This output of Vitamin A is definitely on the lower side since milk output and its Vitamin A content in these mothers cannot be considered optimum. Belavady and Gopalan (1960) observed that a daily supplementation of 2000-10,000 I. U. of Vitamin A to these mothers had no effect on Vitamin A concentration in milk. Since these were undernourished mothers, it is conceivable that this additional supplementation would have been used by the mother for liver storage. The FAO/WHO Expert Group has suggested an additional intake of 450 μg. (1350 I. U.) Vitamin A during lactation. This is based on the daily output of 850 ml. of breast-milk with Vitamin A content of 49 μg./100 ml. This allowance may be suggested for Indian nursing mothers also. The National Research Council of U. S. A. recommends an additional intake of 3000 I. U. of Vitamin A per day during lactation.

7.6.6. Vitamin A requirement of Infants and Children ;

Gopalan (1956) studied growth of infants up to six months and computed their breast-milk intake (Table 17). These infants were growing satisfactorily. From the quantity of milk ingested and the Vitamin A content of milk as determined by Belavady and Gopalan (1959) it appeared that these infants were receiving about 420 I. U. or 140 μg. Vitamin A per day. Considering their growth performance and lack of any Vitamin A deficiency, it may be presumed that this intake of Vitamin A per day represents at least their minimal requirements. It is possible that these are under-estimates and the infants may have been drawing upon their liver stores even at this period of growth. It is not certain whether this low intake provides for liver storage. Perhaps it does not, since many of these children later develop Vitamin A deficiency. Therefore, the above intakes cannot be considered satisfactory. The FAO/WHO Expert Group has presumed that Vitamin A requirement of infants, aged 0-6 months, is met from the Vitamin A ingested through breast-milk. Such intake has been computed to be 420 μg. retinol per day (50 μg./kg). The National Research Council of U. S. A. has recommended 500 mg. Vitamin A for infants.

TABLE 17

Intake of Vitamins by Breast-fed Infants of the Mothers belonging to the Low Socio-economic Group.

Weeks of lactation	Average weight (kg.)	Average milk ingested (ml.)	Calorie intake	Thiamine	Riboflavin	Ascorbic acid	Vitamin A
1	2.78	454	295	69.9	78.1	11.8	318
2	2.92	477	310	73.5	82.0	12.4	334
3	3.12	480	312	73.9	82.6	12.5	336
4	3.27	497	323	76.5	85.5	12.9	348
5	3.72	500	325	77.0	86.0	13.0	350
8	4.20	474	308	73.0	81.5	12.3	332
10	4.40	471	306	72.5	81.0	12.2	330
12	4.57	517	336	79.6	88.9	13.4	362
14	4.83	528	343	81.3	90.8	13.7	370
16	5.11	514	334	79.2	88.4	13.4	360
18	5.37	454	295	69.9	78.1	11.8	318
20	5.57	506	329	77.9	87.0	13.2	354
22	5.77	517	336	79.6	88.9	13.4	362

Vitamin A requirement of the children of other age-groups has been computed by the FAO/WHO Expert Group from the requirement figures for the infants (65-50 μg./kg.) and the adults (12.1 μg./kg.). These two points were joined by a curve based on body-weight increment per kilogram of body-weight at various ages. From this curve, an approximation of the recommended intake of retinol per kilogram of body-weight per day at various ages been computed.

In the absence of reliable data on Vitamin A requirement of Indian infants and children, Vitamin A allowances suggested by the FAO/WHO Committee can be adopted for Indian infants and children for the present.

7.6.7. *Efficiency of Utilization of β-carotene from Foods* :

Since β-carotene from vegetable foods forms a major source of Provitamin A for Indian population, the question of efficiency of its conversion to Vitamin A arises. Though the theoretical conversion ratio of β-carotene to Vitamin A is 0.5, absorption of β-carotene from vegetable sources is reported to be variable and low. From the published literature, the FAO/WHO Expert Group has assumed that the absorption of dietary β-carotene is only 33%. There have been two Indian studies relating to this problem. Wilson *et al.* (1937) reported absorption of carotene from raw carrots and spinach in two subjects on intakes of 113 and 300 mg. carotenes with a typical Bengali diet. Figures for absorption found by them were 77.8 and 87.0 per cent for carrots agd 88.9% for spinach. These authors also observed that on a fat-free diet, absorption of carotene from spinach was only 52.2%, In a recent study at the National Institute of Nutrition Nageswara Rao and Narasinga Rao (1968) determined absorption of crystaline β-carotene and of carotenes from *amaranth, papaya*, carrot and a mixed diet on typical Indian diet containing low fat (15 gm,)in four subjects, carotene intake from the different sources being 5-10 mg. These results are shown in Table 18. Though pure β-carotene was almost completely absorbed, carotenes from food sources were absorbed to the extent of 25-67% only. However, the absorption of β-carotene present in these foods was found to be better absorbed, the values are shown in Table 18. Absorption of total carotenes from green leafy vegetables, fruits like *papaya*, which are cheap sources of Provitamin A, was found to be 58% and 46% respectively. Absorption of β-cartotene from these two sources was found to be 74% and 90% respectively.

TABLE 18

Per cent absorption of carotene from different sourees by Indian subjects

Source	N.I.N. (1968) studies (4 subjects)		Wilson *et al.* (1937) (2 subjects)
	Total carotenes	β-carotene	
Amaranth	58.1 (44.1—79.6)	75.7 (52.4—99.8)	—
Carrot	35.6 (15.9—67.3)	81.1 (73.2—96.8)	82.0
Papaya	45.8 (19.3—63.5)	90.3 (73.3—99.4)	—
β-carotene	—	98·8 (95.4—100.0)	—
Mixed diet	33.4 (15.7—59.2)	—	—
Spinach	—	—	88.9

Based on these observations, it is reasonable to assume that the absorption of carotenes in Indian dietaries on the average will be 50%. Absorption of 33%, adopted by the FAO/WHO Expert Group, appears to be low. If 50% absorption is assumed for availability of carotene from Indian foods, the factor for converting β-carotene values to retinol values will be 0.25. It is suggested that this value may be accepted to convert β-carotene values to retinol while making Vitamin A allowance for Indians.

7.6.8. Loss of Vitamin A and Carotene during Storage and Cooking :

In any consideration of Vitamin A requirement of a population, the possible losses that occur during storage and cooking should be taken into account. Vitamin A is susceptible to storage and cooking losses and carotene less so. The extent of losses depends upon the cooking practice. There are a few studies on the loss of carotene and Vitamin A during storage and cooking as practised in India. De (1936) and Nageswara Rao recently (1967) studied the effect of storage on carotene content of vegetables. It was observed by these workers that generally there was a loss of 15–20% of carotene when the vegetables were stored at room temperature for 24 hours. Cooking losses were, however, small. De and Kshirasagar (1954), Pai (1958*a*) and Hattiangadi and Kanga (1956) studied the loss of Vitamin A in different methods of cooking. Though loss of Vitamin A during boiling was negligible, there was considerable loss (70%) when the foods were fried. Fats fortified with Vitamin A may lose nearly 80% of their Vitamin A content when used for frying. Thus it appears that one can safely presume a loss of 50% of Vitamin A content of foods during storing and cooking as generally practised in Indian homes. Loss of Provitamin A during cooking, however, may be negligible.

7.6.9. Dietary allowances of Vitamin A for Indians ;

Since sufficient data on Vitamin A requirments of Indians are not available at present, the dietary allowances of retinol for different groups suggested by the FAO/WHO Expert Group (1967) may be adopted for Indians. However, in converting the retinol figures to Provitamin A figures, a conversion factor of 4 can be suggested. Four μg. of β-carotene will be equivalent to 1 μg. of retinol. Since most of the Vitamin A source for Indian population will be in the form of β-carotene which is not susceptible to cooking losses as preformed Vitamin A, allowance for cooking losses may not be necessary while recommending dietary allowance of Vitamin A for Indians. Suggested allowances of retinol and β-carotene for Indians are shown in Table 19.

7.7. Vitamin D :

Vitamin D is required for the metabolism of calcium and phosphorus and thus for skeletal growth. Therefore, the relative need of Vitamin D for infants and children is more than for adults. Body needs of Vitamin D can be acquired by dietary intake and exposure to sunlight. It is not possible to determine the quantity of Vitamin D acquired by exposure to sunlight. Dietary intake of Vitamin D is also difficult to assess because rapid and reliable method for the assay of Vitamin D is not available. For the same reason it is difficult to assess the Vitamin D nutritional status by determining blood and tissue levels of the vitamin.

203

TABLE 19

Suggested Daily Allowances of Vitamins for Indians

Group	Vitamin A (μg.)		Thiamine (mg.)	Ribo-flavin (mg.)	Niacin equivalents (mg.)	Ascor-bic acid (mg.)	Folic acid (μg.)	Vitamin B_{12} (μg.)	Vitamin D (I.U.)
	Retinol	β-carotene							
Adults :									
Man	750	3000	1.2	1.3	16	50	100	1	
Woman	,,	,,	1.0	1.0	13				
Pregnancy	,,	,,	,,+0.2	,,+0.2	,,+2	50	150-300	1.5	
Lactation	,,+400	,,+1600	,,+0.4	,,+0.4	,,+5	,,+30	150		
Infants :									
0-6 months	400								
6-12 ,,	300	1200					25	0.2	
Children :									
1-3 years	250	1000	0.6	0.7	8				200
4-9 ,,	300	1200	0.8	0.8	10				
7-6 ,,	400	1600	0.9	1.0	12				
10-12 ,,	600	2400	1.0	1.2	14	30-50	50-100	0.5-1.0	
Adolescents :									
13-15 years									
Boys	750	3000	1.3	1.4	17				
Girls			1.1	1.2	14				
16-19 years									
Boys	750	3000	1.5	1.7	21				
Girls			1.1	1.2	14				

Vitamin D requirement has been most extensively studied in infants in the West (National Research Council, U.S.A., 1964). It has been shown that a daily intake of 300-400 units of Vitamin D permits maximal retention of calcium in infants when the calcium intake is satisfactory. It is doubtful whether this is a satisfactory criterion for the assessment of Vitamin D requirement. While according to the above criterion Vitamin D requirement is in the range of 300–400 units, Vitamin D intake by breast-fed infants, who grow well and do not show signs of Vitamin D deficiency, is much less because Vitamin D content of human milk is only 50 units per litre. Other studies with premature infants show that daily administration of 100–250 units of Vitamin D prevents biochemical evidence of rickets and helps to sustain normal skeletal growth in premature infants fed cow's milk. It is not possible, therefore, to fix from the available data the minimum requirement of Vitamin D. However, in Western countries 400 I.U. of Vitamin D are normally recommended for infants (National Research Council, U. S. A., 1964).

There is no information on the Vitamin D requirement of infants and children under the Indian conditions. Information is also not available on the Vitamin D content of foods consumed in India. It may be assumed that in a tropical country like India, sufficient Vitamin D may be acquired through exposure to sunlight to meet the Vitamin D needs. How much of this endogenously produced Vitamin D is available under Indian conditions, is not known. It may be that requirements of normal adults, which are lower, may be completely met through this source. Also it is possible that the requirement of breast-fed infants may be met by the Vitamin D content of milk (values for which are not available) and by exposure to sunlight, However, epidemiological data indicate that rickets is prevalent in children whose diets do not contain any source of Vitamin D. This would indicate that Vitamin D, that might be acquired through exposure to sunlight by these children, is not adequate to meet their requirements. It appears, therefore, that there is a necessity to provide, especially for children, a dietary source of Vitamin D in addition to what is derived from exposure to sunlight. Lack of any data do not permit an assessment of requirement of dietary Vitamin D by Indians. From the work carried out in Western countries, the requirement may range from 100–400 I.U., depending upon the criteria employed. Under the Indian conditions, where there is a greater scope for meeting part of Vitamin D requirment by the endogenous synthesis through sunlight, levels of Vitamin D recommended in Western countries (*viz.* 400 I.U.) may not be necessary for Indians. Therefore, for the present a level of 200 I.U. of Vitamin D can be tentatively suggested as the dietary allowance of Vitamin D for Indians. It should be emphasised, however, that this figure is purely arbitraory.

7.8. Vitamin C :

7.8.1. *Human Requirement of Vitamin C* :

The minimum requirement of Vitamin C has been determined by controlled

human experiments in U.K. (Medical Research Council, 1953). Human volunteers, kept on 1 mg. Vitamin C per day, developed scurvy in fourteen months. Another group of volunteers, kept on 10 mg. ascorbic acid for the same period, did not develop scurvy. Capillary fragility was, however, poor in the latter group. W.B.C. ascorbic acid was lower in both the groups compared to the values observed in the control group receiving adequate (70 mg./day) Vitamin C. It was concluded from this experiment that minimal human requirement of Vitamin C is 10 mg. a day. The Medical Research Council in U.K. trebled this figure and recommended 30 mg. as the allowance for an adult. The National Research Council of U.S.A. (1964), however, have recommended an allowance of 70 mg./day for adults and 30-80 mg. for infants and children.

7.8.2. *Vitamin C Requirement of Indians* :

There are several studies (Ranganathan and Shankaran, 1937 ; Basu and Ray, 1940*a*) on the urinary excretion of Vitamin C and response to a load test in Indians. These studies indicate that the urinary excretion of ascorbic acid in Indians is generally low and return of a test load in also low. The subjects in the above studies had to be given a supplement of 1000-2000 mg. ascorbic acid, spreadover several days, before the load test in these subjects indicated saturation.

Basu and Ray (1940*a*) attempted to compute the Vitamin C requirement of Indian adults on the basis of urinary excretion studies. Six volunteers who were initially saturated with Vitamin C (200-500 mg./day for 7-8 days) were used in this study. The daily urinary excretion of ascorbic acid on their normal diets, which supplied 18-39 mg. ascorbic acid, and after supplementing daily with 25 mg. ascorbic acid, were estimated. The total daily requirement was computed from the ascorbic acid utilized by the body which was calculated by subtracting urinary excretion from the intake. These authors computed that the daily average utilization in these subjects was 44 mg., or 0.28-0.31 mg. per kg. under the above experimental conditions. The daily requirement of Vitamin C was arrived at by adding the amount of ascorbic acid excreted in urine to the amount utilized by the body. The average figure for the ascorbic acid requirement was found to be 66.2 mg. In considering utilization, only urinary loss was taken into consideration in the above study. Since ascorbic acid is also lost through oxidation, utilization was thus over-estimated in this study. Therefore, the figures arrived at by these authors may be considered to be on the higher side. By keeping the subjects at lower intake levels, entirely different set of figures could have been derived following this approach.

In a recent study by Srikantia *et al.* (1968), Vitamin C requirement was determined in Indian subjects by employing the criterion that the minimum requirement of the vitamin was the level of intake that maintained W.B.C. concentration of the vitamin at saturation level. The subjects had subnormal levels of W.B.C. ascorbic acid to start with. They were given a large daily dose of ascorbic acid (500 mg./day) for several days till their W.B.C. ascorbic acid had reached a maxi-

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mal value. Then their intake was reduced to 10 mg. per day and kept on this intake for several days and W.B.C. level ascorbic acid was determined periodically. It was observed that after some time, W.B.C. levels tended to decline indicating that an intake of 10 mg. per day was below the requirement level. When the intake was raised to 20 mg., however, W.B.C. levels could be maintained at saturation level for as long a period as 100 days. It would appear, therefore, that the minimum requirement of ascorbic acid for the adult is between 10-20 mg./day. This intake would not only meet the minimum needs but would keep the tissue, such as W.B.C., saturated. If individual variability factor of 20% is applied, a figure of 25 mg./day is obtained for the adult requirement for ascorbic acid.

7.8.3. *Pregnancy* :

There are no data to indicate that Vitamin C requirement during pregnancy is increased. The increase due to foetal requirement may be small. Therefore, extra allowance may not be necessary during pregnancy since normal allowance includes sufficient safety margin. A level of intake, which can maintain W.B.C. level of ascorbic acid at saturation level during pregnancy, needs to be determined in Indian women.

7.8.4. *Lactation* :

If ascorbic acid requirement of nursing mother is considered to be the sum of normal adult requirement and the Vitamin C secreted through milk, then the additional allowance during lactation may be about 35 mg. per day. This is based on milk secretion of 850 ml. per day with ascorbic acid concentration of 4.0-5.0 mg. per100 ml. Indian women from the poorer socio-economic group, however, secrete only 600 ml. milk, with an average ascorbic acid content of 2.6 mg. per 100 ml. When these women were supplemented with a large daily dose of ascorbic acid, its level in milk could be raised to 4-5 mg. per 100 ml. In well-nourished Indian women also, ascorbic acid content of milk has been shown to be 4.5 mg./100 ml. (Deodhar and Ramakrishna, 1959). Belavady and Gopalan (1960) investigated the effect of supplementation of ascorbic acid on the content of this vitamin in breast milk of nursing mother belonging to the low socio-economic group. It was observed by these workers that a supplementation of 200 mg. ascorbic acid per day was necessary to raise milk ascorbic acid level to a maximum. It is not clear whether the intake of this order is really necessary to maintain milk concentration at the maximal level. Large part of this high intake would have gone to saturate the tissues of the mother herself. Also, since this supplement was given as a single dose, plasma level would be so high that a large proportion of the vitamin would be eliminated in urine. It may not be essential to achieve a maximal concentration of ascorbic acid or any other water-soluble vitamin in milk if, even at lower concentrations, the total vitamin ingested may be able to satisfy the infant's need. For example, nursing mothers belonging to the low socio-economic group put out only 15 mg. ascorbic acid through milk, which apparently satisfies the infant's need. It may be necessary to employ other criteria, like the W. B. C. levels of ascorbic acid in the mother, to judge the adequacy of the dietary intake by the mother during lactation.

7.8.5. *Infants* :

Considering the ascorbic acid intake of breast-fed infants (0-6 months) studied by Gopalan (1956), it can be concluded that an intake of 15 mg. ascorbic acid would satisfy the daily requirement of this vitamin in young infants. If an adult's requirement of ascorbic acid, to maintain W. B. C. saturated, is 10-20 mg. per day, a daily intake of 15 mg. ascorbic acid by the infant may be considered more than adequate.

7.8.6. *Children* .

Ascorbic acid requirement of children should then be between 15-25 mg.

Sufficient information is available form Indian work to conclude that ascorbic acid requirement for Indians range from 15 to 25 mg. for different age-groups. During lactation, however, an additional intake of 15 mg. per day may be necessary.

7.8.8. *Loss of Vitamin C during cooking* :

Ascorbic acid is one of the vitamins which is readily lost during storing and cooking. There have been a few studies on the loss of ascorbic acid on storing and cooking as practised in Indian homes. Pasricha (1967) studied ascorbic acid losses in sixteen varieties of vegetables rich in ascorbic acid. Losses in ascorbic acid on storing at room temperature and in refrigerator were 35% and 12% in case of leafy vegetables ; 19% and 8% in the case of tubers, respectively. Cooking losses varied from 0 to 80%, greater losses occurring during frying. Pai (1957) reported ascorbic acid loss in different food preparations varying from 22 to 78%. Rudra (1937) has also reported similar losses for cauliflower and spinach cooking and storage. For practical consideration, one may assume that on the average about 50% of Vitamin C, as contained in raw foods, is lost during keeping and cooking as practised in Indian homes. Since Vitamin C in Indian dietaries is derived mostly from cooked-vegetables and only to a small extent from raw vegetables and fruits, safety margin for these losses has to be made in any practical allowance of Vitamin C for Indians. The recommended allowance of Vitamin C should, therefore, be at least twice the requirement level if allowance is made for cooking losses. The suggested allowance for the vitamin, based on the foregoing consideration, are given in Table 19. In arriving at these allowances, the requirement figures have been doubled to allow for cooking losses.

7.9. Thiamine :

Thiamine, as the cofactor for cocarboxylase, is intimately involved in carbohydrate metabolism. It has been recognized for a long time that thiamine requirement is related to carvohydrate calorie intake.

7.9.1. *Human requirement of thiamine ;*

Diet surveys indicate that an intake of 0.4 mg. thiamine per 1000 calories, or below, is associated with thiamine deficiency. Beriberi has been shown to be associated with thiamine intakes of 0.3 mg. per 1000 calories. Subjects suffering from

Beriberi have been observed to excrete 0-15μg. thiamine daily in urine. It has also been shown that urinary excretion of 5-20 μg. of thiamine per day is associated with intakes of 0-2 mg. per 1000 calories. Urinary clearance studies have indicated a daily requirement of 0.33-0.35 mg. per 1000 calories, and intake required for tissue saturation has been found to be 0.35 mg. per 1000 calories. Controlled human depletion studies have indicated that 0.23 mg. per 1000 calories did not result in deficiency signs over a period of 10-12 weeks (Keys *et al* , 1943). In another carefully conducted study (Horwitt *et al.*, 1948), an intake of 0.2 mg. per 1000 calories was found to be below the minimal requirement. Taking the results of all these studies, the Expert Group of the FAO/WHO (1967) have concluded that the minimum requirement of thiamine is 0.33 mg. per 1000 calcries, and with a 20% allowance for individual variability an intake of 0.4 mg. thiamine per 1000 calories has been considered to meet the human requirement of thiamine. The National Research Council of U.S.A. (1964) has recommended a daily allowance of 1.12 mg thiamine, the calorie allowance being 2900. This figure also corresponds to 0.4 mg. per 1000 calories.

7.9.2. *Thiamine requirement of Indians* :

Diet Surveys : The average intake of thiamine by Indians, as indicated by several diet survey data, appears to be apparently adequate, especially when considered in relation to inadequate calorie intake. The intake values vary over a wide range and these intakes have not been corrected for losses that might occur during cooking, which can be considerable. No reliance can, therefore, be placed on these figures as being actual intake values. It is not possible to obtain from the diet survey data an idea of the minimum requirement of thiamine.

Urinary excretion studies : There are a few studies conducted in Indian subjects on urinary excretion of thiamine on known intakes. Though these studies were not planned with the specific objective of assessing thiamine requirement, these data can be used to obtain an idea of thiamine excretion in Indians on different levels of intakes and to obtain an estimate of intake associated with a level of urinary excretion consistent with good thiamine nutrition status. Thiamine excretion of 70μg./gm creatinine (or 100-140μg./day) is shown to be associated with an intake of 0.4 μg. per 1000 calories which satisfies human requirement. Ahmed and Guha (1938) studied urinary thiamine excretion of four healthy subjects living on different Indian dietaries. On intakes ranging from 1200-1425 μg. (0.49-0.62 mg. per 1000 calories) the range of excretion was 84-228 μg. per day. On lower intakes ranging from 600-680μg. (0.24 to 0.37 mg. per 1000 calories). excretion was 25-36 μg. Thiamine intakes in this study were based on raw diets. This study would indicate that thiamine intake of 0.29 mg. per 1000 calories is associated with low excretion. Ramasastry *et. al.*. (1950) studied urinary excretion of thiamine in 15 human volunteers on family or laboratory controlled diets. In 98 observations, the excretion was found to range between 66-1200 μg. with intakes ranging from 0.3-0.77 mg. per 1000 calories. These intakes were calculated from thiamine content of raw foods and thus no allowance was made for cooking losses. Pyruvic and lactic acid levels in these subjects were within the normal range. There was no correlation between intake and excretion

and there was also considerable variation between individuals. The majority of the subjects had intakes around 0.4 mg./1000 calories and showed a mean daily excretion of 105-500 μg. Ramanamurthy and Gopalan (1966), in their studies on raw and parboiled rice, observed that the urinary excretion of thiamine in four subjects ranged from 90-700 μg. per day when the intake from raw rice was 341-700 μg. per 1000 calories. Intakes of 385-420 μg thiamine per 1000 calories resulted in a daily excretion of 104-200 μg. thiamine per day. The intakes were computed from the analysis of the cooked diets.

The above studies would indicate that an intake of 0.4-0.5 mg. thiamine per 1000 calories is adequate as judged by the urinury excretion of thiamine.

Transketolase activity : Thiamine requirement of young Indian women has been recently studied at the National Institute of Nutrition by Bamji (1968). Four young women were placed on a basal diet containing 0.1 mg. thiamine per 1000 calories for a period of fifteen days and at the end of this period, transketolase activity of R.B.C. and the urinary excretion of thiamine were estimated. After a preliminary depletion period, thiamine was added to their diet at weekly intervals to raise their intake to 0.2 mg. per 1000 calories and then to 0.4 mg. per 1000 calories. Transketolase activity of R.B.C. and the urinary excretion of thiamine were again estimated at the end of a week's supplementation at these two levels. It was observed that a dietary intake of 0.20 mg. per 1000 calories was sufficient to maintain transketolase activity at the maximal level. At this level of intake, urinary excretion was 94μg./gm, creatinine which remained unaltered when the intake was reduced to 0.1 mg. per 1000 calories, but did increase (190 μg. 94 μg/gm. creatinine) when the intake was raised to 0.4 mg. per 1000 calories. From both these criteria, it would appear that the minimum requirement of thiamine by young women is 0.2 mg. per 1000 calories. If 20% allowance for individual variability is made the requirement figure will be 0.25 mg. per 1000 calories. This figure is based on actual intake obtained by analysis of the cooked diet. If it were based on raw diet content the corresponding intake should be about 0.5 mg./1000 calories, allowing for 50% cooking loss. Data obtained from urinary excretion studies described earlier also support this figure of 0.5 mg. per 1000 calories for thiamine allowance for Indians.

7.9.3. *Thiamine requirement in pregnancy* :

Transketolase activity in R. B. C. and the urinary excretion of thiamine in twentytwo pregnant women and fourteen normal women has been studied by Bamji (1968). It was estimated that the thiamine intake of the pregnant women was in the neighbourhood of 0.5 mg. per 1000 calories. Though transketolase activity in R. B. C, of the pregnant women was found to be significantly lower than that in the normal women, there was no clinical evidence of thiamine deficiency. An intake of 0.5. mg, of thiamine per 1000 calories in these pregnant women could not be considered inadequate though this level of intake was not able to maintain transketolase activity of R.B.C. at normal level. The FAO/WHO Expert Group did not recommend any extra allowance of thiamine per 1000 calories for pregnant women and assumed that extra thiamine intake corresponding to increased calorie intake during pregnancy would take

care of any additional need. The National Research Council of U.S.A. recommends 2.0 mg. additional intake during pregnancy. It is suggested that thiamine allowance for Indian women during pregnancy also be 0.5 mg. per 1000 calories and that the total daily allowance may be related to their calorie allowance.

7.9.4. *Lactation* :

The WHO/FAO Expert Group assumed that as in the case of pregnancy, extra intake corresponding to extra calorie intake would meet the thiamine requirement of nursing mothers. The National Research Council of U.S.A. recommended additional intakes of 0.3 mg/day. Thiamine secreted in breast-milk by Indian women of the low socio-economic group was found to be 90μg. per day. This computation is based on breast-milk content of 15μg. thiamine per 100 ml. and a daily excretion of 600 ml. of milk by the nursing mothers belonging to the low socio-economic group. Ramasastry and Indravati (1957) observed that the thiamine concentration of breast-milk ranged from 3.1 to 25.5 μg/100 ml. with an average of 12.2 μg. per 100 ml. Deodhar and Ramakrishna (1959) reported thiamine content of 13.8 μg. per 100 ml. of breast-milk in the higher income-group and 10.5 μg. in the lower income-group. Belavady and Gopalan (1959) reported thiamine concentration of 15.5 μg. per 100 ml. in breast-milk of Indian women belonging to the low socio-economic group. This corresponds to about 250 μg. per 1000 calories. Belavady and Gopalan (1960) also studied the effect of thiamine supplementation on the breast-milk content of thiamine in these nursing mothers. Thiamine content of milk could be raised to a maximum of 20μg./100 ml. with continued supplementation of 10 mg. thiamine per day. Assuming an optimal thiamine content of 20μg/100 ml. and a milk output of 850 ml, additional thiamine requirement for nursing mothers would be about 0.17 mg. per day if extra thiamine requirement during lactation is equivalent to that secreted in milk. Extra thiamine allowance corresponding to the extra calorie allowance for nursing mother, computed on the basis that their requirement also is 0.5 mg. per 1000 calories, will be 350 μg. per day which is about twice the quantity of thiamine secreted daily in milk. It is, therefore, suggested that thiamine allowance for Indian women during lactation may be computed from their calorie allowance, their thiamine requirement being the same as for adults, *i. e.*, 0.5 mg. per 1000 calories.

7.9.5. *Infants* :

From the controlled study of Gopalan (1956) on breast-milk intake and growth of infants of 0-6 months, it can be computed that thiamine intake of these children was about 90μg. (Table 17). Considering their satifactory growth, this intake of thiamine would have satisfied their minimal needs since this intake roughly corresponded to 250 μg. per 1000 calories. With optimal thiamine content of 20 μg. per 100 ml; and milk output of 850 ml/day, thiamine intake of infants will not be more than 170 μg. per day.

7.9.6. *Children*:

It is suggested that thiamine requirement of Indian children of different age-groups can be estimated on the basis of recommended calorie allowance, assuming that

their thiamine requirement also is related to calorie intake, *i.e.* 500 μg. per 1000 calories, in the same way as for adults. The calculated figures are shown in Table 19.

7.9.7 *Thiamine requirement in relation to other factors* :

Since thiamine is needed for carbohydrate metabolism, its requirement can be expected to be higher when dietary calories are derived predominantly from carbohydrates, a situation that exists in Indian dietaries. On the other hand, intestinal biosynthesis of thiamine may be favoured by a carbohydrate diet. To what extent thiamine requirements of Indians are modified by these factors, is not known precisely.

7.9.8 *Thiamine losses during cooking* :

Thiamine being a heat labile vitamin, its losses may be significant during cooking. Basu and Malankar (1946*)* observed that thiamine retention in some vegetables during cooking was about 60%. Pai (1958*b*) found that in several food preparations, thiamine loss varied from 1.7 to 53%. Pasricha (1963) reported that thiamine retention ranged from 30 to 80% in several Indian food preparations. Thiamine loss in rice was shown to be considerable during washing, a loss which is more marked than during cooking. Thus, one may expect an average loss of about 50% thiamine present in raw foods, during cooking as practised in Indian homes. When allowance for losses are to be made, thiamine requirement figures, based on actual intakes, will, therefore, have to be doubled to obtain dietary allowance of thiamine in terms of the vitamin present in the raw food.

7.9.9. *Dietary allowance of thiamine* :

Based on the data reviewed above, it is suggested that thiamine allowance for Indians will be 0.5 mg. thiamine per 1000 calories. Total daily allowances of thiamine, calculated from the calorie allowances for different groups, are shown in Table 19.

7.10. **Riboflavin** :

Though it is generally considered that the riboflavin requirement is related to protein content of the diet, FAO/WHO Expert Group considered that its requirement was best expressed on the basis of calorie intake since flavin nucleotides take part in energy metabolism also. It has also been shown that consideration of its requirement on either basis yields similar results.

7.10.1. *Human requirement of riboflavin* :

The FAO/WHO Expert Group computed human riboflavin requirement from the available data on diet surveys and controlled depletion-repletion studies. It has been shown that population groups consuming less than 0.7 mg. riboflavin per day, show high incidence of clinical symptoms of riboflavin deficiency and excrete a low level of riboflavin (40 μg./day) in urine. In depletion studies, clinical evidence of triboflavin deficiency was observed at intakes of 0.15 mg. per 1000 calories in women

and at 0.22 or 0.25 mg. per 1000 calories in men. On intakes of 0.31–0.36 mg. per 1000 calories, urinary riboflavin markedly reduced to 50 μg, per day. It has also been recorded that 0 41 mg. per 1000 calories intake of riboflavin for over two years did not result in any deficiency symptoms. The relationship between the urinary excretion of riboflavin and its intakes that, as the intake is reduced, urinary excretion reduces sharply up to an intake of 0.44 mg per 1000 calories ; below this level urinary excretion reduces only slowly. Taking all these observations into consideration, the FAO/WHO Expert Group concluded that the minimum requirement of riboflavin was 0.44 mg/1000 calories. With an allowance of 20% for the individual variation, the Group suggested dietary allowance of 0.55 mg. riboflavin per 1000 calories. The National Research Council of U.S.A. (1964) has recommended an allowance of 1.7 mg. riboflavin for an intake of 2900 calories or 0.586 mg. per 1000 calories.

7.10.2. *Riboflavin requirement of Indians* :

Diet Survey : Results of diet surveys, carried out in India, indicates that the intake of riboflavin vary over a wide range and even the average intake figures are below the requirement figures. These values were calculated from diet survey data using Food Composition Tables (Indian Council of Medical Research : Special Report No. 42). The values for riboflavin, based on chemical assay method, given in these tables, appear to be high. Subsequent estimation, employing microbiological methods, have yielded lower values for the riboflavin content of several foods. Hence intakes, based on the earlier diet survey results, must be an overestimate. Further, these intakes are based on raw foods and do not include losses that might occur during cooking. Therefore, a significant proportion of the persons surveyed must have had riboflavin intakes much below the requirement level, and this low intake explains the high incidence of angular stomatitis observed among the poorer segments of Indian population.

Urinary excretion studies : Though specific studies designed to evaluate the riboflavin requirement of Indians are not available, there are a few studies in Indians on the urinary excretion of riboflavin on known intakes which are useful for assessing their reboflavin requirments. Ramasastry *et al.* (1950) determined, employing the fluorometric method, urinary excretion of riboflavin in fifteen subjects on known intakes ranging from 0.76 to 1.91 mg. or 0.34 to 0.62 mg. per 1000 calories. All the subjects excreted fairly large amounts of riboflavin, ranging from 343 to 4401 μg., with an average of 1243 μg. In many of the subjects, excretion exceeded intake. High excretion in these subjects may be due to contribution from the intestinal biosynthesis. Even at intakes of 0.4 mg. per 1000 calories, urinary excretion was fairly high. Pargoankar and Srikantia (1964) studied urinary excretion of riboflavin in 45 subjects with different nutritional background and with a wide range of riboflavin intakes which were assessed by oral questionnaire diet survey. Riboflavin was estimated microbiologically. The data are shown in Table 20. It was observed that subjects belonging to the low socio-economic groups, some of whom manifested riboflavin deficiency, excreted only 46.5-48.1 μg. riboflavin per day, with riboflavin intakes of 363 μg. per 1000 calories. On the other hand, subjects from the higher income group, with intakes of 528 μg. riboflavin per 1000 calories, excreted

TABLE 20

Intake and Urinary Excretion of Riboflavin in different Groups of Indians

Subjects	No. of subjects	Calorie intake	Riboflavin intake		Riboflavin excretion (μg./24 hours)
			Total/day	per 1000 calories	
Well-to-do	13	2350	1.24	0.53	158·9
Low income	36	1900	0.69	0.36	46.5
Pregnancy	10	1573 (975-2000)	0.57	0.36	43.6

159 μg. riboflavin per day which can be considered satisfactory. Pregnant women also were found to excrete only 43.6 μg. riboflavin per day. Red cell levels of riboflavin were significantly higher (20 μg. per 1000 ml.) in subjects of high income-group with satisfactory riboflavin intake than the levels (12 μg./1000 ml) in low income subjects with poor intakes. Swaminathan (1942) reported that his subjects excreted 320-350 μg. riboflavin a day on intakes of 1.2-1.5 mg per day. Calorie contents of their diets, however, are not known. Ramakrishna (1963) has reported riboflavin excretion in normal subjects as being 690 μg./day but their riboflavin intakes have not been given. Assuming that excretion of 120 μg-/day is associated with a riboflavin intake satisfying its minimal requirement, the above studies indicate that an intake of 360 μg. per 1000 calories is below the requirement level. An intake of 500-530 μg. per 1000 calories, however, appears to be satisfactory as judged by the urinary excretion. These can be at best only a rough estimate because the intakes in these studies were not determined by actual analysis of the diets. The above intakes relate to riboflavin content of raw foods as riboflavin intake in the above studies were computed from the raw foods and no further allowance need be made for cooking losses. These values are not different from the figures for riboflavin requirement given by the FAO/WHO i. e., 0.55 mg. per 1000 calories. It can, therefore, be suggested that riboflavin allowance for Indians may be 0.55 mg. per 1000 calories.

7.10.3. *Pregnancy ;*

There are no specific studies on riboflavin requirement of Indian women during. pregnancy. Riboflavin excretion is known to be increased during late pregnaucy. The FAO/WHO Expert Group did not suggest any additional allowance per 1000 calories and was of the opinion that extra riboflavin intake correspoding to the extra calories allowance during pregnancy would take care of the additional needs of the vitamin in this condition. The National Research Council of U.S.A. has recommended an additional intake of 0.3 mg. during pregnancy. It is suggested that for Indian women also daily riboflavin allowance during pregnancy may be comupted from their calorie allowance on the basis of riboflavin requirement of 0.55 mg. per 1000 calories.

7.10.4. *Lactation* :

The FAO/WHO Expert Group has argued that extra riboflavin intake corresponding to extra calories recommended (1000 calories) would more than compensate for riboflavin excretion in milk (0.32 mg.) The National Research Council of U.S.A recommends 0.6 mg. additional intake of riboflavin. This corresponds to 0.6 mg. per 1000 calories of additional calories recommended during lactation.

There have been extensive studies on the riboflavin content of breast milk of Indian women. Belavady and Gopalan (1959) reported an average value of 17.2 μg./100 ml. (or 260 μg. per 1000 calories) forriboflavin content of breast milk of nursing mothers belonging to the low socio-economic group. Deodhar and Ramakrishna (1959) have reported riboflavin content of breast milk of nursing mothers belonging to various income-groups. Belavady (1962) has attempted to evaluate riboflavin requirement of nursing mothers (10 subjects) by supplementing riboflavin at different levels, the period of supplementation at each level being 3-4 weeks. It was observed than an intake of 3 mg. riboflavin per day, in addition to their daily intake of 0.3-0.5 mg., resulted in a maximal concentration of 30 μg. riboflavin per 100 ml. of milk. Whether such high levels of intake represent the optimum requirement of lactating women, or whether part of the supplementation had gone to saturate the tissue of these subjects, is not easy to ascertain. The question may also be asked whether maximal milk concentration of riboflavin is necessary from the point of view of satisfying infants needs. It is necessary, therefore, to determine the ribofiavin requirement of lactating women in terms of her riboflavin nutritional status when her lactation performance is satisfactory. Assuming that optimal concentration of milk riboflavin is 30 μg./100 ml., riboflavin secretion through milk would be 180 μg if 600 ml. is the total milk output, or 225 mg. for an optimal daily milk output of 750 ml. Thus it can be suggested that additional daily intake of riboflavin during lactation should be at least 0.25 mg. per day. Additional allowance of riboflavin corresponding to the extra calorie allowance during lactation will be 385 μg. (0.55 mg. per 1000 calories) which is more than the amount of riboflavin secreted in milk. It is suggested that extra allowance of riboflavin for Indian women during lactation may be computed from calorie allowance, assuming her requirement is also 0.55 mg. riboflavin per 1000 calories.

7.10.5. *Infants and children* :

The FAO/WHO Expert Group have assumed in the absence of other data that riboflavin intake of 0.55 mg. per 1000 calories would satisfy the needs of infants and children. The riboflavin intake of Indian infants of 0-6 months of age, with satisfactory growth, can be computed (Table 17) from the data of Gopalan (1956) and of Belavady and Gopalan (1959). The riboflavin intake of 102 μg. per day appears to satisfy the minimal needs of these infants, These intakes correspond to about 250 μg. per 1000 calories. There are no data available on the riboflavin requirement of Indian children of other age-groups. It is suggested that the allowances, for the older children can be computed from calorie

allowances, assuming that in this age-group also the requirement is about 0.55 mg. per 1000 calories.

7.10.6. *Loss during cooking* :

Though riboflavin is a heat stable vitamin, it is sensitive to light. As with other vitamins, cooking losses occur in the case of riboflavin also. Pai (1958*b*) reported riboflavin losses ranging from 0.15 to 48% in different Indian food preparations. Pasricha (1963) has reported riboflavin retention in several foods ranging from 23 to 100% during cooking, retention being higher than in the case of thiamine. Perhaps, an average loss of 30% can be assumed for riboflavin.

7.10.7. *Dietary allowance of riboflavin* :

Taking into consideration the limited data on the riboflavin requirement of Indians, which have been reviewed above, suggested scales of allowances of riboflavin are mentioned in Table 19. Riboflavin allowances were calculated from the calorie allowances, the basic allowance being 0.55 mg. per 1000 calories.

7.11. **Nicotinic Acid.**

Nicotinic acid, as part of a co-enzyme, takes part in glycolysis and tissue respiration and hence its requirement is related to energy metabolism. However, niacin has a special relationship with protein in that the amino acid tryptophan can be converted to niacin in the body. Thus dietary tryptophan can spare niacin. In any consideration of niacin requirement, dietary niacin and tryptophan should be taken together. It is generally accepted that 60 mg. of tryptophan is equivalent to 1 mg. niacin. Dietary allowances are usually made in terms of niacin equivalents which are computed from the niacin and tryptophan content of the diets.

7.11.1. *Requirement of niacin* :

Carefully conducted human studies indicate that an intake of 4.4 mg. niacin equivalents just prevents symptoms of pellagra. Further, addition of 10 gm. lactalbumin to the diets of these subjects, or a total intake of 5.5 mg. niacin equivalents per 1000 calories, caused increased excretion of metabolites in some subjects and an intake of 7.7 mg. niacin equivalents increased the excretion of metabolites in all the subjects. The FAO/WHO Group accepted a figure of 5.5 mg. niacin equivalent per 1000 calories as the minimum requirement, and with an allowance of 20% for the individual variability the niacin requirement figure becomes 6.6 mg. per 1000 calories. The National Research Council of U.S.A. have suggested an allowance of 19 mg. of niacin equivalents per day which corresponds to about 6.6 mg. per 1000 calories.

Results of diet surveys, carried out in India, indicate that the average intake of niacin is 18.5 mg. Limitation of these diet survey data precludes drawing any definite conclusion regarding the dietary adequacy of niacin in Indian subjects. However, careful diet survey of a very large number of pellagrins, admitted to the

Osmania General Hospital, by workers of the National Institute of Nutrition indicated a mean intake of 43 gm. protein, 7.2 mg. nicotinic acid, 0.45 gm. tryptophan and 1960 calories (Table 21). These intakes correspond to 14.7 mg. of niacin equivalents per day or 7.5 mg. niacin equivalents per 1000 calories. Though this is a satisfactory intake, it has been shown by the work at the National Institute of Nutrition that pellagra can develop on such diets predominantly based on *jowar* due to the presence of excess of leucine in it. On the basis of niacin intakes alone, these patients are definitely having subminimal intakes of niacin *i.e.*, 3.6 mg. per 1000 calories. It can be said that in the absence of tryptophan or with inefficient conversion of tryptophan to niacin, an intake of 3.6 mg. of niacin per 1000 calories is definitely below the minimal requirement. Aykroyd

TABLE 21

Dietary Intake of Nicotinic Acid and Tryptophan by Pellagrins

	Calories K. Cal. day	Nicotinic acid mg./day	Trypto-phan mg./day	Total nico-tinic acid equivalents mg./day*	Nicotinic acid equivalents mg./1000 cals
Men	1960	7.3	450	14.8	7.6
Range	1090-3400	4.2-10.5	340-1100	—	

*Nicotinic acid $+ \frac{\text{Tryptophan}}{62}$

and Swaminathan (1940) noted that pellagra is rare among poor rice eaters. On these diets niacin intakes ranged from 5 to 11 mg.: the lowest figure being on diets containing milled cooked rice. With total calories of 2300 and protein content of 45 gm., such a typical diet predominantly based on rice (milled) contains 6.00 mg. niacin equivalents per 1000 calories. This level can be considered to satisfy niacin requirement of the group studied by the above authors. This level is not different from the niacin requirement figure suggested by the FAO/WHO Expert Group.

De and Banerjee (1948) studied nicotinic acid requirement of Indian adults. Body requirement was determined in five subjects subsisting on rice diets providing 2585 calories and 64.5 gm. protein and 540 mg. tryptophan. Employing the criterion suggested by Briggs *et al.* (1945) *viz.*, that a return of 15% of a dose of 500 mg. nicotinic acid is consistent with adequate niacin nutrition, the above authors concluded that niacin intake of 7.8 to 9.6 mg/day was adequate since their subjects, who were on these intakes, excreted 19–20% of a 500 mg. load of niacin. Total niacin intakes of thise subjects, including contribution from tryptophan, was 16.8 to 18.6 mg. niacin equivalents. On the basis of calories, the intakes were 6.5 mg. to 7.2 mg. niacin equivalents per 1000

calories. These levels of intake appeared to be adequate as per criteria employed in this study.

These studies would indicate that the dietary allowance of 6.6 mg. niacin equivalents per 1000 calories, suggested by the FAO/WHO Expert Group, corresponds to intakes in Indian population in whom incidence of pellagra is rare. These intakes are based on raw food content. There is no Indian work bearing on the efficiency of conversion of dietary tryptophan to niacin under different dietary and physiological conditions. However, when the protein intake corresponds to the recommended allowance, the contribution of tryptophan towards niacin nutriture can be expected to be normal and a conversion factor, which is generally accepted, may hold good under these conditions also. It can, therefore, be suggested that the dietary allowance of niacin for Indians may be fixed at 6.6 mg. niacin equivalents per 1000 calories.

7.11.2. Pregnancy and lactation :

The conversion of tryptophan to niacin appears to be more efficient in pregnancy. The FAO/WHO Expert Group have concluded that there is no need for any additional allowance per 1000 calories during pregnancy and lactation and any additional need is met by the additional allowance corresponding to the increased calorie allowance. The National Research Council of U. S. A. recommended 3 mg. and 7 mg., respectively, of additional allowances of niacin equivalents during pregnancy and lactation respectively. These roughly correspond to 7 mg. niacin equivalents per 1000 calories.

No information is available on the niacin requirement in Indian women during pregnancy and lactation. There are only limited data on the breast milk content of nicotinic acid. Deodhar and Ramakrishna (1960) have reported nicotinic acid content of 103 to 150 μg/100 ml. in breast-milk of different groups of lactating women whose dietary intakes on niacin ranged from 2 to 7 mg. per day. Nicotinic acid output in breast-milk of Indian mothers will range from 0.5 to 1.0 mg. per day if the average daily breast-milk output is 600 ml. Another 1.5 mg. niacin equivalents may be derived from tryptophan content of milk proteins. Then the total niacin equivalents derived from breast-milk may about 2.5 mg. per day. It is suggested that the dietary allowance of niacin for Indian women during pregnancy and lactation may be based on the recommended calorie allowance, the base allowance of niacin being 6.6 mg. niacin equivalents for 1000 calories. This will more than compensate for the niacin secreted in breast-milk.

7.11.3. *Infants and children* :

According to the FAO/WHO Expert Group, basic recommendation of 6.6 mg. of niacin per 1000 calories is assumed to hold good for children and for infants. Indian infants of 0-6 months of age would be receiving about 2.5 mg. niacin equivalents per day (10 mg. niacin equivalents per 1000 calories) through breast-milk which apparently satisfies their niacin requirements. Total daily niacin allowance for Indian children may be computed from the recommended calorie allowance. using the requirement figure of 6.6 mg. niacin equivalents per 1000 calories.

7.11.4. *Effect of cooking on niacin* :

Though niacin is more stable than other B-complex vitamins, losses have been reported to occur during cooking. In different Indian food preparations, Pai (1958) has reported loss of 2.4 to 37%, and Pasricha has reported loss of 0 to 75% (Average loss of about 25%). An average loss of 25% can be assumed for nicotinic acid during cooking as practised in Indian homes.

7.11.5. *Dietary allowance of niacin :*

It can be suggested from the limited data bearing on niacin requirement of Indians, which have been reviewed above, that niacin requirements of our population are satisfied by an allowance of 6.6 mg. niacin equivalents per 1000 calories. Based on this, daily allowances of niacin, calculated from the calorie allowance, are mentioned in Table 19. It is assumed that protein intake is normal while suggesting these levels.

7.12. **Vitamin B_{12} .**

Besides thiamine, riboflavin and niacin, there are several other B-group vitamins required by human subjects. They are pyridoxine, biotin, pantothenic acid, PABA, inositol, folic acid and Vitamin B_{12}. However, specific deficiency symptoms directly attributable to deficiencies of pyridoxine, biotin, PABA and inositol, have not been described in detail so far in human beings. It is known that a specific clinical syndrome attributable to pantothenic deficiency occurs in human subjects but there are, as yet, no data on pantothenic acid requirement of human subjects. It is perhaps for this reason that specific recommendations regarding the requirements for these vitamins for humans are not generally made. It is also possible that several of these vitamins are present in most common foods in amounts sufficient to satisfy the normal human requirements.

On the other hand, deficiencies of folic acid and of Vitamin B_{12} are known to occur in man, and hence the human requirements for these two vitamins may have to be considered, especially in view of the wide prevalence of nutritional anaemia in our country. Therefore, a discussion of human requirements of folic acid and B_{12} and how far they are fulfilled in Indian dietaries becomes necessary when nutrient allowances of Indians are considered. There have been no studies on the requirement of Vitamin B_{12} and folic acid in Indians. Data reported in Western countries on the human requirement of these two vitamins have to be resorted to in arriving at the dietary allowances of these two vitamins for Indians.

7.12.1. *Vitamin B_{12} (Cyanocobalamin)* :

Though the metabolic role of Vitamin B_{12} is not completely understood, several coenzyme functions in the body have been attributed to Vitamin B_{12}. Important among these, as they relate to megaloblastic anaemia, are its functions in the synthesis of nucleic acids and in folic acid metabolism.

7.12.2. *Human requirement of Vitamin B_{12}* :

It is estimated that the Vitamin B_{12} content of diets in Western countries may vary from 3 to 30 μg. Vitamin B_{12} absorption from the intestinal tract is regulated by

the intrinsic factor present in gastric juice. Crystalline Vitamin B_{12} is known to be absorbed to the extent of 70% at a low dose of 0.5 μg., but at higher doses of 5 μg., only 30% is absorbed. Vitamin B_{12} present in food may be absorbed to a different extent depending upon the level of Vitamin B_{12} present in it.

Vitamin B_{12} is stored in the body, mostly in the liver. The liver stores have been estimated to be 800 to 1100 μg. Longterm excretion studies, using radioactive cobalt labelled B_{12}, indicate that about 0.1% of the body stores is lost per day. Therefore, in a normal person with liver stores of 1 to 1.5 mg. vitamin B_{12}, 1-1.5 μg. of absorbed vitamin B_{12} may be lost per day. A diet containing 3 to 5 μg. vitamin B_{12} may be able to compensate this loss. On the other hand, it is reported that as small a dose as 0.1 μg. vitamin B_{12}, given parenterally, causes a positive reticulocyte response in meglobastic anaemia, suggesting thereby that the minimal requirement would be of this order. For sustained responses, however, doses of 0.5 μg. or more are necessary. It is suggested, a level three times this, *i.e.*, 1.5 μg./day will be able to keep the body stores at adequate levels and meet the demands of the body for various needs of this vitamin. Cooking losses and a decrease in Vitamin B_{12} levels during processing, like converting milk into curds, have been reported (Lichtenstein *et al.*, 1961). Little is known about the absorption of Vitamin B_{12} from foods.

The published evidence, therefore, suggests that the human requirement for Vitamin B_{12} may be about 0.5 μg. of absorbed vitamin. However, an allowance should be made for the possible wide differences in the extent of absorption of the vitamin from foods and also for the possible losses of the vitamin during cooking. Hence it may be suggested that a daily dietary allowance of 1·0 to 1.5 μg. of Vitamin B_{12} would meet the human needs for this vitamin. In view of difficulty in achieving in Indian dietaries high intakes of vitamin B_{12}, which is entirely derived from foods of animal origin, a modest allowance of 1.0 μg. vitamin B_{12} per day can be suggested for the Indian adult.

7.12.3. *Vitamin B_{12} intake of Indians* :

The average In dian diet is largely based on foods of vegetable origin like cereals and pulses which do not contain any Vitamin B_{12}. Diet survey data (Visweswara Rao, 1967) indicate that the average intake per consumption unit of milk and milk products is 69 gm. and that of fiesh foods, 19 gm. On such intakes of foods of animal origin, daily intake of Vitamin B_{12} works out to be about 0.7 μg. This lexel of Vitamin B_{12} intake, though appearing to satisfy just the minimal needs, cannot be considered optimal. Moreover, the figures given above for the intake of animal foods are averages for the population as a whole, and in a vast majority of population, animal foods do not find a place in the diets or their intake is irrsgular, so that Vitamin B_{12} deficiency can be expected to be widely prevalent in the community. Determination of serum Vitamin B_{12} also suggest low Vitamin B_{12} status in our population. It is sometimes suggested that Vitamin B_{12} requirement of vegetarians is at least in part satisfied by intestinal biosynthesis. However, such contribution by intestinal biosyntheis does not appear to be much as evidenced by the low levels of serum B_{12} levels in such subjects (Satyanarayana, 1963). The

conclusion is inescapable therefore that there is sufficient justification to recommned intake of animal foods at least as a source of Vitamin B_{12} for Indian population. If a modest allowance of Vitamin B_{12} of 1 μg./day is considered to be essential, 250 ml. of milk, 100 gm. of flesh food or 30 gm. eggs must be included in the daily diet of an adult. These are in fact the levels actually recommended for a balanced diet earlier. Such levels of animal foods provide not only Vitamin B_{12} but also some high quality animal protein and in the case of milk, calcium.

7-12.4. *Vitamin B_{12} requirement during pregnancy and lactation* :

As with other nutrients, during pregnancy and lactation, additional VitaminB_{12} is required to provide for foetal storage and milk secretion, respectively. Vitamin B_{12} nutrition of expectant and nursing mothers, belonging to the low socio-economic group, must be very poor as judged by the dietary pattern and incidence of anaemias in this group. If 300 μg./ml. is considered the normal concentration of Vitamin B_{12} in breast-milk (Gregory, 1954), total daily output of Vitamin B_{12} will be 0.2-0.25μg., depending on milk output. During pregnancy, foetal storage of Vitamin B_{12} may be considred to be around 50-100 μg., and to provide for this an additional 0.2-0.4μg. of absorbed Vitamin B_{12}/day is necessary. Therefore, during pregnancy and lactation an additional intake of 0.5 μg. of dietary Vitamin B_{12} may be expected to take care of the additional needs. Pregnant and nursing mothers should, therefore, receive daily a total of 1.5 μg vitamin B_{12} through their diets. This means, the allowance of animal foods in these should be higher than that suggested above for adults.

7.12.5. *Vitamin B_{12} needs of infants* :

Vitamin B_{12} deficiency anaemia in breast-fed infants, receiving low amounts of Vitamin B_{12} (0.03-0.05 μg.), have been described by Srikantia and Vinodini Reddy(1967). Analysis of Vitamin B_{12} content of milk of mothers of children with megaloblastic anaemia showed an average level of 75 p.g./ml. The above intake is obviously below the requirement levels for infants. Normal concentration of Vitamin B_{12} in breast-milk is reported to be 300 p.g./ml. On this basis, Vitamin B_{12} intake of breast-fed infants will be in the range of 0.18-0.25 μg./day, depending on milk Intake. Vitamin B_{12} requirement of infants can, therefore, be considered to be satisfied with an intake of 0.2 μg./day. Vitamin B_{12} allowance for children may be between 0.5-1.0 μg.

In summary, the Vitamin B_{12} nutritional status of Indians is generally poor and inclusion of animal foods to provide Vitamin B_{12} in their diet is essential. An intake of animal foods providing daily 1 μg. vitamin B_{12} can be suggested for an adult. During pregnancy and lactation, an additional daily intake of 0.5 μg. vitamin B_{12} should be provided. Such level may be considered necessary not only for the health of the mother but for the healthy growth of the foetus.

7.13. **Folic Acid** :

The biochemical function of folic acid as a one-carbon donor in the biosynthesis of various metabolites in the body is now fairly well established. Folic acid deficiency results in megaloblast maturation arrest, glossitis and gastro-intestinal tract disturbances.

Folic acid is present both in vegetable and animal foods. Some of the vegetable foods like green leafy vegetables are rich sources of folic acid. Folic acid occurs both in the free and conjugated forms although the former is believed to the physiologically available.

7.13.1. *Human requirement of folic acid* :

As little as 25 μg of crystalline folic acid can bring about haematological response consistently in patients with megaloblastic anaemia due to folic acid deficiency. A daily intake of 50 μg. folic acid has been shown to prevent depletion of serum folic acid, but 25 μg. does not, suggesting that the daily requirement of folic acid would be of the order of 50 μg. in the free form (Herbert, 1962). However, in view of the lack of information on the equivalent of this amount in terms of the folate content of foods and also on the extent of absorption of forms of folates present in foods, a definite recommendation cannot be made regarding the allowance of folic acid. Even so, it may be considered that a diet containing 100 μg. free folic acid (*L. casei* activity) may be adequate to meet the folic acid requirement of an adult. Dietary allowance of 100 μg. free folic acid can, therefore, be suggested for an Indian adult.

7.13.2. *Folic acid intake of Indians* :

Anaemia due to folic acid deficiency is frequenly encountered in poorer segments of population, especially during pregnancy. Though folic acid occurs widely in vegetable foods, some segments of Indian population show folic acid deficiency. Free folic acid content of cereals range from 5 to 32 μg. per 100 gm., while that of pulses ranges from 23 to 69 μg./100 gm. (Lakshmiah, 1968). Green leafy vegetables are rich source of folic acid and contain 50 μg. of free folic acid per 100 gm. Folic acid (free) intake on a poor Indian diet, based mainly on cereals and pulses, with little of leafy vegetables, appears to be only about 37 μg. if the cereal is entirely rice, 100 μg. if wheat or other millets form the cereal, and 70 μg. on mixed cereal diet. Hence it is apparent that folic acid intake of groups, subsisting mainly on rice, is well below the requirement level. In order to bring this intake up to the suggested allowance level, *i. e.*, 100 μg. free folic acid per day, the diet, especially rice-based ones, should contain at least 100 gm. of green leafy vegetables.

7.13.3. *Pregnancy and lactation :*

Folic acid requirements in these conditions are not known with certainty. Normal daily output of folic acid in breast-milk is 20-25 μg. Indian women belonging to the poor socio-economic group may be secreting only about 10 μg. since folate level in their milk is about 1.6 μg./100 ml. compared to a normal level of 3.0 μg./100 ml. (Ramasastri, 1965). It can therefore, be assumed that in the case of a lactating mother, additional 50 μg. of folic acid (free) daily may meet this extra need. The suggested daily allowance of folic acid for Indian women during lactation will then be 150 μg. free folic acid per day. The requirement of folic acid in pregnancy is known to be increased. It is known that the urinary

excretion of folic acid during pregnancy is higher than normal. A daily intake of 50 μg free folic acid, which can maintain serum levels of folic acid in normal adults, fails to do so in pregnant women. Supplementation studies by Willioughby and Jewell (1966) indicate that the minimal requirement of folic acid in late pregnancy, to maintain serum folate levels, is close to 300 μg. per day. In the absence of any precise data on the folic acid requirements, a daily allowance of 150-300 μg. of free folic acid may be suggested for Indian women during pregnancy.

7.13.4. *Infancy*:

Infants on breast-milk will be consuming 20-25μg. of folic acid per day if the milk concentration of folic acid is normal (30-40μg./ 100ml). Infants born to poor mothers will be receiving only 10 μg. folic acid per day since their milk concentration of folic acid is low. It is not quite certain whether the latter levels satisfy folic acid requirement of these infants totally. Therefore, folic acid allowance during infancy should be 25 μg. For children, a daily allowance of 50-100 μg. of folic acid can be suggested.

Dietary allowance of Vitamin B_{12} and folic acid, based on the above data, have been given in Table 19. It should be pointed out, however, that these are based on very limited Indian data and more work is necessary on the requirement of these vitamins by Indians, especially during pregnancy.

7.14. *Summary* :

(a) Available information on the vitamin requirement of Indians has been reviewed. Very few studies have been specifically designed to obtain information on vitamin requirements.

(*b*) No precise data on Vitamin A requirement of Indians are available. Therefore, the scales of Vitamin A allowances, suggested by the FAO/WHO Expert Group, can be adopted for Indians. Availability of Provitamin A from foods, especially green leafy vegetables, is about 50%. A factor of 0.25 is suggested to convert β-carotene value to retinol values.

(*c*) The need for dietary allowance of Vitamin D has been discussed and an arbitrary allowance has been suggested.

(*d*) From careful studies on Vitamin C requirement, it appears that the daily requirement of ascorbic acid in Indians to sustain tissues (W.B.C) in saturation is 25 mg./day. It is suggested that this figure may be doubled to allow for cooking losses.

(*e*) From studies on urinary excretion of thiamine and R.B.C. transketolase levels on known intakes in Indians, thiamine requirement can be placed at 0.5 mg. per 1000 calories. This figure is in terms of thiamine contained in raw foods.

(*f*) Similarly urinary excretion studies on riboflavin in Indians on different intakes indicate that an intake of 0.55 mg. per 1000 calories. derived from raw foods, appears to meet the daily requirement of riboflavin.

(*g*) Very few studies are available on niacin requirement of Indians. From the available data, it can be suggested that 6.6 mg. niacin equivalents per 1000 calories is the niacin requirement of Indians.

(*h*) In view of the wide prevalence of nutritional anaemia in India, requirements of Vitamin B_{12} and folic acid have also been discussed. Dietary allowance of these two vitamins has been indicated.

(*i*) Based on Indian data, and the dietary allowances of different vitamins suggested by the FAO/WHO Expert Group, dietary allowances of these vitamins for Indians have been indicated. These are summarized in Table 19.

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8. AREAS FOR FURTHER RESEARCH

It is evident from the foregoing discussions that there are a number of areas in which further research is needed to clarify and supplement our knowledge regarding the nutrient requirements of Indian subjects. With regard to calorie and protein requirements, data are already available and these have to be further enlarged. With regard to nutrients like Vitamin A, Vitamin D and calcium, available data are extremely meagre, and extensive studies are needed. Research is also needed on certain related problems like availability of nutrients from foods and interaction of environment and other factors on requirement. Some of the areas of research, which can be undertaken in the near future, may be briefly discussed.

8.1. Calories :

There is very little information on the calorie requirement of children and adolescents. More data on BMR and energy expenditure in this age-group are needed to compute their calorie requirements more accurately. Precise data on the body-weight of normal Indian children needs to be collected to enable the computation of their daily requirements of calories and other nutrients. As regards the calorie requirements during pregnancy and lactation, BMR in a larger number of these subjects, the efficiency of conversion of dietary calories to milk calories, and the pattern of physical activity during pregnancy need yet to be determined.

8.2. Proteins :

Despite considerable data which are available on the protein requirement of Indians, there are aspects of the problem on which further research is needed. One such important area is related to the protein requirement of Indian children and the efficiency of utilization of dietary protein by them. Protein requirements during pregnancy and lactation have been usually computed by the factorial approach. A more direct determination of protein requirement in these conditions is necessary to assess the possible hormonal influence on their protein requirements. A study of the influence of dietary protein level on the body-weight gain and birth-weight of babies will be useful in assessing protein requirement during pregnancy. Another area of research is the determination of the efficiency of conversion of dietary protein to milk protein during lactation. Even as regards the protein requirement of adults, the influence of environment and physical activity on the requirement have yet to be determined. Related to this is the determination of sweat loss of nitrogen in Indians under different conditions.

8.3. Calcium :

The entire area of calcium requirement of Indians is yet to be fully explored. Studies on calcium requirement, especially of children and the pregnant and lactating

women, have to be undertaken. Another interesting problem is the possible influence of pregnancy and lactation on the efficiency of utilization of dietary calcium. Information on the availability of calcium from several Indian foods has also to be collected.

8.4. Iron :

Though much work has been done on the iron requirement of Indian adults, information regarding the iron requirement of children has yet to be collected. As regards the iron requirement during pregnancy and lactation, a direct approach to this problem by determining the minimum dietary iron intake to sustain their iron nutritional status may be useful. Availability of iron from foods, especially those rich in iron, like certain millets, will have to be determined.

8.5. Vitamins :

Requirements with respect to several vitamins have yet to be determined. Some of the problems in this area are the following :

(*a*) The requirement of Vitamin A and Vitamin D in Indian subjects have not been yet determined. Determination of the requirement of these two vitamins, especially by children, should receive immediate attention. Precipitation of osteomalacia during pregnancy, frequently seen among women of low socio-economic status, suggests that Vitamin D requirement during pregnancy may be increased. The problem of Vitamin D requirement during pregnancy, therefore, deserves careful study. Related to the problem of Vitamin D requirement is the establishment of a good method for its estimation in foods and blood. A more difficult but necessary research is about the extent of availability of Vitamin D through exposure to sunlight under Indian conditions.

(*b*) Determination of riboflavin and niacin requirement by a more systematic method is necessary. The efficiency of conversion of dietary tryptophan to niacin in Indians has yet to be determined.

(*c*) Requirement of Vitamin B_{12} and folic acid in Indians has not so far been investigated. Assessment of requirement of these two vitamins in pregnancy should receive special attention.

(*d*) Availability of several B-complex vitamins, especially of folic acid, from different foods needs to be determined.

(*e*) Requirement of water-soluble vitamins during pregnancy and lactation will have to be determined, employing the maintenance of tissue saturation in the mother as the criterion.

8.5.1. *Other nutrients* :

The requirement of minor B-complex vitamins, like pyridoxine, has not been discussed. But there is a need to obtain information on the human requirement of these vitamins and to ascertain how far Indian dietaries fulfil them. The requirement of pantothenic acid also deserves careful investigation. It is known that significant amounts of pantothenic acid are secreted in milk and this drain of pantothenic acid during lactation may partly account for the high incidence of "burning feet" in lactating women.

Similarly the human requirements of several micronutrients like copper, zinc, molybdenum etc., have to be studied more systematically since the role of these elements in human nutriition is being recognized more and more.

8. 6. General problems :

The question of individual variability in the nutrient requirement, interaction of nutrents on each other's requirement, influence of stress, unusual environment on nutrient requirements, the relation between infection, infestation and malnutrition to nutrient requirement, are some of the problems to which further research should be directed.

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APPENDIX I.

DIETARY ALLOWANCES OF NUTRIENTS AND BALANCED DIETS FOR INDIANS.

Recommendations made by the Nutrition Expert Group of the Indian Council of Medical Research in 1968 :

The Nutrition Expert Group at its meeting held in the National Institute of Nutrition, Hyderabad, considered the question of revision of the nutrient allowances for Indians on the basis of the document prepared by Dr. C. Gopalan and Dr. B. S. Narasinga Rao and made the following recommendations :

Calorie requirements :

The calorie requirements of Indians, as recommended in 1958, were adopted without change except in a few cases. In the case of calorie allowance for women (both for sedentary and moderate work), a discrepancy was pointed out between the recommended figures and the computed figures, unlike in the case of men. It was, therefore, recommended that calorie allowances for women for sedentary and moderate work be reduced to 1900 and 2200, respectively, to remove the discrepancy.

So far as the calorie allowance for women during pregnancy was concerned, it was realised that it was difficult to quantify physical activity during pregnancy under Indian conditions. It was, therefore, recommended that the calorie allowance during pregnancy should be given in the form of additional allowance of 300 calories per day during the latter half of pregnancy. During lactation, an additional allowance of 700 calories per day up to one year of lectation was recommended.

In the case of adolescents alterations were made in the recommended allowances. Since in the 1958 recommendations the calorie allowances for children of 10–12 years were the same as for adolescent girls (13–15 and 16-18 years), the caloric allowances for the latter were changed from 2000 to 2200 to cover the increased need of calories during adolescence. The calorie allowance for adolescent boys (16–18 years) was reduced from 3150 to 3000.

The question of calorie allowance for heavy work was discussed in the light of special needs of soldiers working at high altitudes and at low temperatures. Since the present recommendations are for people working under normal conditions it was pointed out that the allowance of 3900 calories for heavy work does not include allowance for special conditions like the one mentioned above. However, it was agreed that a special

allowance should be made for increased calorie requirements under unusual conditions like army men working at high altitudes and at low temperatures.

Proteins :

The protein allowances for Indians which were recommended in 1944 and 1958 were reconsidered in the light of new experimental data on this subject. The protein allowance for adults was recommended as 1 gm/kg. body weight of a mixed protein of N.P.U. of 65. The daily protein allowance recommended were 55 gm. for adult men and 45 gm. for adult women.

During the latter half of pregnancy, and additional allowance of 10 gm. of protein of N. P. U. 65 was recommended. During lactation, an additional allowance of 20 gm. of protein was recommended up to one year of lactation.

The protein requirement of infants up to six months was considered to be met entirely from milk, and the recommended allowances during this period will be entirely in terms of milk proteins. Since it was realised that infants between 6 to 12 months, though continue to receive some breast-milk, are likely to receive supplementary feeds in the form of vegetable proteins, protein allowance based on mixed proteins of N. P. U. 65 was recommended for this group. The Expert Group pointed out, however, that even during this period milk protein will continue to form a significant part of the infant's protein intake. The recommendations for infants were given terms of requirement per kg. of body-weight as per the usual practice because of the fast rate of growth. It was also recommended that the total daily allowance of protein for infants should be calculated on the basis of 'ideal' bodyweight rather than on actual bodyweight.

Protein allowances for children were computed by the factorial approach in terms of dietary proteins of N. P. U. value of 50–60.

Calcium :

The Expert Group recognised the need for a downward revison of calcium allowance from the high level recommended earlier in view of the fact that population groups can thrive well on much lower calcium intakes. Since sufficient information is not available to fix the calcium requirement of various groups accurately, the Expert Group agreed that the range of allowance, as suggested by the FAO/WHO Expert Group on calcium requirements, can be accepted for Indians also for the present. In the absence of definite date on the utilisation of calcium during pregnancy and lactation, a 50% efficiency was assumed and 1 gm. of calcium was recommended in these conditions. For infants and children also, the level suggested by the FAO/WHO Expert Group was accepted. The level suggested for infants will be in the case of artificial feeding only. Calcium requirements of breast-fed infants will be met through breast-milk.

Iron :

Iron requirements of different groups arrived at by the factorial approach were discussed and 20 mg. iron per day was recommended for an adult man and postmenopausal

woman. For woman, during her reproductive life, a daily allowance of 30 mg. of iron was recommended, the additional 10 mg. being required to compensate for menstrual loss of iron. During pregnancy, 40 mg. of iron was recommended throughout pregnancy. During lactation, 30 mg. of iron was recommended if there was no menstruation, and 35 mg. of iron was recommended for lactating women who have started menstruating. For adolescent boys and girls, 5 mg. of iron over and above the corresponding adult allowance was recommended to take care of the increased requirement during adolescence. For infants, 1 mg. of iron per kg. body-weight was recommended. For children, no specific recommendations were made for different age-groups but a daily intake of 15 to 20 mg. iron was considered to be adequate.

Fat :

The Expert Group felt that there were no specific criteria to fix the requirement level with certainty. However, the Expert Group felt that a minimum level of fat in the diet was necessary to provide essential fatty acids and to facilitate absorption of fat soluble vitamins in the diet. It was, therefore, suggested that at least 15 gm. of vegetable oil derived from sesame, safflower or groundnut should be present in the diet to provide the essential fatty acids. Since a level of fat in the diet providing more than 40% of total calories may be deleterious to health, the Expert Group felt that an upper limit of fat in the diet corresponding to 30% of calories would be desirable. This suggested range of fat in the diet applies to all groups. The Expert Group felt that it was not possible to suggest any particular level of fat that is desirable in diet and, therefore, gave an indication of the desirable upper and lower limits.

Vitamin A :

In the absence of specific information on Vitamin A requirement of Indians, the level recommended by the FAO/WHO Expert Group, namely 750 μg. of retinol per day, was accepted and recommended for Indian adults. Since this is a fat soluble vitamin stored in the liver, it was felt that allowances for individual variability and safety margins were not necessary. Based on the observations of the carotene absorption from different foods in Indian subjects, a factor of 0.25 was suggested to convert β-carotene values to retinol values. It was suggested that allowance figures should be given in terms of both retinol and β-carotene. Since most of the Vitamin A in the Indian dietaries is derived from β-carotene; and β-carotene destruction during cooking is considerably small, no allowance for cooking was made in recommending Vitamin A allowances.

Since extra Vitamin A stored in foetus is of small magnitude, no additional allowance was suggested during pregnancy and it was considered that even the normal intake would take care of any additional requirements during this condition. During lactation, an additional allowance of 400 μg. of retinol or 1600 μg. of β-carotene was suggested to compensate for Vitamin A losses in milk. Vitamin A requirement for infants and children were also made on the same scales as suggested by the FAO/WHO Expert Group since no information was available on Vitamin A requirement of Indian

Vitamin D :

The Expert Group recognized that though no definite information is available on Vitamin D requirements of Indians, epidemiological data show that Vitamin D deficiency exists in children who do not receive any dietary Vitamin D, indicating that their Vitamin D requirement is not fully met by the Vitamin D obtained through exposure to sunlight. Though it is accepted in Western countries that daily requirement of Vitamin D is 400 I.U,, no definite indication as to Vitamin D requirement of Indians could be given in the absence of any experimental evidence. Therefore. an arbitrary daily allowance of 200 I.U. of Vitamin D was recommended for all groups. It was felt that this allowance, together with some Vitamin D which may be derived from exposure to sunshine, would meet Vitamin D requirements.

Vitamin C :

The Expert Group recommended a daily allowance of 50 mg. of Vitamin C for adults. This was based on the requirement (25 mg.) to keep the WBC in saturation and the requirement figure was doubled to allow for cooking losses. No additional allowance of Vitamin C was recommended during pregnancy. An additional allowance of 30 mg. corresponding to 15 mg. of Vitamin C secreted in milk was suggested during lactation, bringing the total daily allowance to 80 mg. No specific recommendations were made for children of different age-groups. Daily allowance of 30 mg. of Vitamin C for infants and of 30 to 50 mg. for other childern were considered adequate.

Thiamine, Riboflavin and Nicotinic acid :

Dietary allowances of thiamine, ribofiavin and nicotinic acid were considered to be related to the calorie needs, and allowances of these vitamins were based on calorie allowances.

Thiamine :

The Expert Group recommended an allowance of 0.5 mg. thiamine per 1000 calories. This figure was arrived at by doubling the minimum requirement of 0.25 mg. per 1000 calories to allow for losses during cooking, which may be considerable in the case of rice. Using this basic allowance, the daily thiamine allowances for various groups were computed from the calorie allowances.

Riboflavin :

The Group recommended a figure of 0.55 mg. of riboflavin per 1000 calories and the daily allowances were calculated from the calorie allowances. Since this recommended level of 0.55 mg. per 1000 calories is related to the content of riboflavin in the raw foods, no separate allowance for cooking losses was suggested.

Nicotinic Acid :

The Expert Group recommended an allowance of 6.6 mg. niacin equivalents per 1000 calories. Total daily allowances were calculated from the calorie allowances In making this niacin allowance, both the niacin content and the tryptophan content of the diets were taken into consideration, 60 mg of tryptophan being equivalent to 1 mg. of niacin.

Vitamin B_{12} and Folic Acid :

Among the other vitamins required by the body, folic acid and Vitamin B_{12} were especially considered important in view of their relationship to nutritional anaemia prevalent in our country. Though the Expert Group recognized that no Indian data were available regarding the requirement of these vitamins, it felt the need for making specific recomendation on the dietary allowances of these two vitamins based on available information in literature on the human requirement of these two important vitamins.

Recognizing that 1 μg. of Vitamin B_{12} per day would meet the adult requirements, daily allowance of 1 μg. of Vitamin B_{12} was recommended for the adult. In pregnancy and lactation, an additional allowance of 0.5 μg. of Vitamin B_{12} was recommended; the total allowance being 1.5 μg. per day. The infant's requirement of Vitamin B_{12} was computed to be 0.2 μg. per day. For children, a daily intake of 0.5 to 1.00 μg. of Vitamin B_{12} was recommended.

An allowance of 100 μg. per day of folic acid was recommended for the adult by the Expert Group. This allowance will be in the form of free folic acid (*L.casei* activity without the use of conjugates) present in foods. During lactation. an additional daily allowance of 50 μg. folic acid was recommended. During pregnancy, however, a range of 150-300 μg. folic acid was recommended in the absence of definite information on the folic acid requirement of Indian women during pregnancy, and in view of the reported requirement of folic acid during pregnancy being as high as 300 μg. per day.

A daily allowance of 20μg. of folic acid for infants and 50-100 μg. folic acid for childern was recommended.

Dietary allowances of different nutrients, as recommended by the Expert Group, are mentioned in Table 22.

GENERAL OBSERVATIONS

In view of the wide prevalence of infection, infestation, and anaemias in large segments of Indian population, the Expert Group recognized that that there would be a need for higher allowances in these conditions. However, it was made clear that the figures, which have been recommended for dietary allowances of different nutrients, are for normal Indian subjects in good health. The Expert Group also indicated that in all cases where stress factors like cold climate, high altitude or extreme physical exercise, are operating, suitable extra allowances of the concerned nutrients must be made to meet such special stress situations. While discussing the nutrient needs, especially of calories and proteins, the question of body weight of childern was raised. Since the body-weights of children drawn from the poorer sections of the population are below normal, it was recognised that these levels could not be taken as standard for calculating the daily needs.

BALANCED DIET

The Expert Group also formulated some low-cost balanced diets for the different categories of persons, based on the recommended levels of different nutrients. In formulating such diets, the following criteria were employed.

(1) The diets should be such as would conform to the prevailing dietary and culinary practices.

(2) The diets should be as inexpensive as possible.

(3) They should provide the essential nutrients in adequate quantities.

(4) They should be based on ingredients which are locally available and acceptable.

The balanced diets for different groups, as recommended by the Expert Group, are mentioned in Tables 23 to 26.

TABLE 22

Daily Allowances of Nutrients for Indians

(Recommended by the Nutrition Expert group in 1968)

Group	Particulars	1 Net calories	2 Proteins (gm.)	3 Calcium (gm)	4 Iron (mg.)	5 Vitamin A: Retinol (μg.)	5 Vitamin A: or β-carotene (μg.)	6 Thiamine (mg.)	7 Riboflavin (mg)	8 Nicotinic acid (mg.)	8 Ascorbic acid (mg.)	9 Folic acid (μg.)	10 Vitamin B_{12} (μg)	11 Vitamin D (I.U.)
Man	Sedentary work	2400	55a	0.4-0.5	20	750	3000	1.2	1.3	16	50	100	1	
	Moderate work	2800						1.4	1.5	19				
	Heavy work	3900						2.0	2.2	26				
Woman	Sedentary work	1900	45a	0.4-0.5	30a	750	3000	1.0	1.0	13	50	100	1	
	Moderate work	2200						1.1	1.2	15				
	Heavy work	3000						1.5	1.7	20				
	Pregnancy (second half of pregnancy)	+300	+10a	1.0	40b	750	3000	+0.2	+0.2	+2	50	150-300a	1.5	
	Lactation (upto 1 year)	+700	+20a		30c	1150	4600	+0.4	+0.4	+5	80	150		
Infants	0—6 months	120/kg.	2.3-1.8/kg.a	1.0mg./kg		400	—				30	25	0.2	200
	7—12 ,,	100/kg.	1.8-1.5/kg.	0.5-0.6		300	1200							
Children	1 year	1200	17	0.4-0.5	15-20	250	1000	0.6	0.7	8	30-50	50-100	0.5-1.0	
	2 years		18											
	3 years		20											
	4—6 years	1500	22			300	1200	0.8	0.8	10				
	7—9 years	1800	33			400	1600	0.9	1.0	12				
	10—12 years	2100	41			600	2400	1.0	1.2	14				
Adolescents	13—15 yrs. Boys	2500	55	0.6-0.7	25	750	3000	1.3	1.4	17				
	Girls	2200	50		35			1.1	1.2	14				
	16—18 yrs. Boys	3000	60	0.5-0.6	25	750	3000	1.5	1.7	21				
	Girls	2200	50		35			1.1	1.2	14				

Footnotes to the Table on Daily Allowances of Nutrients for Indians (i.e. Table 1)

1. *Calories* :

(*a*) Calorie allowance for heavy work does not include work under special conditions like high altitude.

2. *Proteins* :

(*a*) Adult allowance corresponds to 1 gm./kg. of dietary protein of N.P.U. 65.

(*b*) Infant allowance during 0–6 months is in terms of milk proteins. During 7–12 months, part of protein intake will be protein in the form of milk, and supplementary feeding will be derived from vegetable proteins. Total daily protein allowance is calculated from the ideal weight. Protein allowances during infancy will be :—

0–3 months	2.3 gm./kg.
3–6 months	1.8 gm./kg.
6–9 months	1.8 gm./kg.
9–12 months	1.5 gm./kg.

(*c*) Allowances for children and adolescents have been computed using body-weights as obtained in the well-nourished groups and assuming N.P.U. of 50 for the dietary proteins.

3. *Calcium* :

In the absence of precise information on calcium requirement of different groups, a range of allowance has been suggested.

(*a*) Calcium allowance for infants 0–6 months will be for artificially fed infants. Calcium intake from breast milk will, however, satisfy the needs of breast-fed infants up to 6 months.

4. *Iron* :

(*a*) This allowance of 30 mg. iron is for adult woman during her premenopausal period. For the post-menopausal woman, iron allowance is the same as for man.

(*b*) This allowance for pregnant woman will be throughout pregnancy.

(*c*) This allowance is for lactating woman who is not menstruating. If a woman is lactating and also menstruating, her iron allowance will be 35 mg./day.

5. *Vitamin A* :

Dietary allowance for Vitamin A is given in terms of retinol (Vitamin A alcohol) and β-carotene. Either of these is used, depending upon the dietary source of vitamin. The factor to be used to convert β-carotene to retinol is :

1 μg. of β–carotene = 0 25 μg. of retinol.

If the diet contains both Vitamin A and β–carotenes, its content can be expressed as retinol, using the following formulae .

(*i*) Retinol content μg. = μg. retinol + μg. β–carotene x 0.25
if the retinol and β-carotene content of foods are given as μg. in the food composition tables.

(*ii*) Retinol content (μg.) = Vitamin A (I.U.) x 0.3 + β-carotene (I.U.) x 0.15 if the Vitamin A and carotene values are given in terms of International Units.

6,7,8. *Thiamine, Riboflavin and Nicotinic acid* :

The daily allowance of these three vitamins are related to calorie intake.
The basic allowances per 1000 calories are.

Thiamine = 0.5 mg., Riboflavin = 0.55 mg., and Niacin = 6.6 mg. niacin equivalents.

Niacin allowance includes contribution from dietary tryptophan,

60 mg. tryptophan being equal to 1 mg. niacin.

Niacin equivalents in a diet are computed as follows :

$$\text{Niacin equivalents (mg.)} = \text{Niacin content (mg.)} + \frac{\text{tryptophan content (mg.)}}{60}$$

9. *Folic Acid* :

Dietary allowance of folic acid will be in terms of free folic acid (*L. casei* activity) present in foods.

(*a*) Folic acid requirement appears to be considerably increased during pregnancy. Since the exact requirement is not known, a range, rather than a single figure, has been suggested for the daily allowance of folic acid during pregnancy.

10. *Vitamin B_{12} ;*

Vitamin B_{12} is derived entirely from foods of animal origin.

11. *Vitamin D* :

Since the exact requirement of Vitamin D is not known, an arbitrary allowance of 200 I. U./day is made. This allowance is in addition to some amount of Vitamin D that might be derived form exposure to sunlight.

12. *Fat :*

Since human requirement of fat is not known, no specific allowance is recommended. A desirable range for fat in the diet is, however, indicated. Diet should contain at least 15 gm. fat derived from vegetable oils like sesame, safflower or groundnut. It is also desirable that calories derived from fat in the daily diet should not exceed 30% of total calories.

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TABLE 23

Balanced Diets for Adult Man

	Sedentary work		Moderate Work		Heavy Work	
	Vege-tarian (gm.)	Non-vege-tarian (gm.)	Vege-tarian (gm.)	Non-vege-tarian (gm.)	Vege-tarian (gm.)	Non-vege-tarian (gm.)
Cereals	400	400	475	475	650	650
Pulses	70	55	80	65	80	65
Green leafy vegetables	100	100	125	125	125	125
Other vegetables	75	75	75	75	100	100
Roots and tubers	75	75	100	100	100	100
Fruits	30	30	30	30	30	30
Milk	300	100	200	100	200	100
Fats and oils	35	40	40	40	50	50
Meat and fish	—	30	—	30	—	30
Egg	—	30	—	30	—	30
Sugar and Jaggery	30	30	40	40	55	55
Groundnuts	—	—	—	—	50*	50*

*An additional 30 gm. of fats and oils can be included in the diet in place of groundnuts.

TABLE 24

Balanced Diets for Adult Woman

	Sedentary work		Moderate work		Heavy work		Additional allowances during	
	Vegetarian	Non-vegetarian	Vegetarian	Non-vegetarian	Vegetarian	Non-vegetarian	Pregnancy	Lactation
	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)
Cereals	300	300	350	350	475	475	50	100
Pulses	60	45	70	55	70	55	—	10
Green leafy vegetables	125	125	125	125	125	125	25	25
Other vegetables	75	75	75	75	100	100	—	—
Roots and tubers	50	50	75	75	100	100	—	—
Fruits	30	30	30	30	30	30	—	—
Milk	200	100	200	100	200	100	125	125
Fats and oils	30	35	35	40	40	45	—	15
Sugar and jaggery	30	30	30	30	40	40	10	20
Meat and fish	—	30	—	30	—	30	—	—
Eggs	—	30	—	30	—	30	—	—
Groundnuts	—	—	—	—	40*	40*	—	—

*An additional 25 gm. of fats and oils can be included in the diet in place of groundnuts.

TABLE 25

Balanced Diets for Adolescent Boys and Girls

	Boys				Girls	
	13—15 years		16—18 years		13—18 years	
	Vege tarian	Non-vege-tarian	Vege-tarian	Non-vege-tarian	Vege-tarian	Non-vege-tarian
	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)
Cereals	430	430	450	450	350	350
Pulses	70	50	70	50	70	50
Green leafy vegetables	100	100	100	100	150	150
Other vegetables	75	75	75	75	75	75
Roots and tubers	75	75	100	100	75	75
Fruits	30	30	30	30	30	30
Milk	250	150	250	150	250	150
Fast and oils	35	40	45	50	35	40
Meat and Fish	—	30	—	30	—	30
Eggs	—	30	—	30	—	30
Sugar and Jaggery	30	30	40	40	30	30
Groundnuts	—	—	50*	50*	—	—

* An additional 30 gm. of fats and oils can be included in the diet in place of groundnuts.

TABLE 26

Balanced Diets for Children

	Pre-school Children				School Children			
	1—3 Years		4—6 years		7—9 years		10—12 Years	
	Vegetarian	Non-vegetarian	Vegetarian	Non-vegetarian	Vegetarian	Non-vegetarian	Vegetarian	Non-vegetarian
	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)
Cereals	150	150	200	200	250	250	320	320
Pulses	50	40	60	50	70	60	70	60
Green leafy vegetables	50	50	75	75	75	75	100	100
Other vegetables Roots and tubers	30	30	50	50	50	50	75	75
Fruits	50	50	50	50	50	50	50	50
Milk	300	200	250	200	250	200	250	200
Fats and oils	20	20	25	25	30	30	35	35
Meat and fish Eggs	—	30	—	30	—	30	—	30
Sugar and Jaggery	30	30	40	40	50	50	50	50